

## Developments in dairy cow fertility research





## RESEARCH TEAM

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# FOREWORD

## The Challenge

Poor reproductive performance is a major problem on dairy farms throughout Northern Ireland. Farmer surveys conducted by AgriSearch have consistently ranked it as a high priority. Indeed one of the earliest dairy research projects funded by AgriSearch was an on-farm study involving 19 herds across Northern Ireland (Table 1). This study recorded an average conception rate to first services of 41%, which is very much in line with similar studies conducted by the University of Nottingham and the University of Reading. This compares with conception rates of 55% in the early 1980's.

Table 1. Range in fertility performance across 19 Northern Ireland dairy herds recorded between 1999 and 2001

	Average	Range (Min-Max)	Achievable Target *
Interval to first service (days)	84	67-119	73
Heat Detection Rate (%)	72	55-89	82
Conception Rate (%)			
To 1 <sup>st</sup> A.I.	41	18-61	55
To 2 <sup>nd</sup> A.I.	40	19-58	55
To all A.I.	39	22-53	50
Overall (A.I. & natural service)	44	30-60	55
Calving Interval (days)	404	371-447	380
Re-appearance Rate (%)			
365-day	24	4-45	35
400-day	44	22-65	60
100-day In-calf Rate (%)	46	16-71	65

\* average of top 5 herds

Although declining dairy cow fertility is equally concerning in many other parts of the world, some of the highest yielding and most productive herds in the UK are able to maintain excellent fertility. This clearly demonstrates that poor fertility performance is not an inevitable consequence of modern dairy systems.

## The cost of poor fertility

Poor fertility is recognised as having many consequences, both direct and indirect. These include:

- Loss of milk production through too many dry days or peak yield traded for later lactation yield
- Disruption to the calving season and milk production pattern
- Loss of mature animal milk yields through early culling
- Extra veterinary treatment costs
- Reduced calf sales
- Additional AI costs
- Enforced culling, resulting in more replacements being reared or bought
- Loss of valuable genetics
- Linkage with other problems such as nutritional imbalances and production shortfalls

The financial implications of poor fertility on UK dairy farms are detailed in Table 2. These losses are significant. However, it is the widely held view among veterinary surgeons and experienced dairy advisors that many of these losses are avoidable.

Table 2: The cost of poor fertility in a 100 cow herd averaging 7,000 litres (recorded between 1999 and 2001)

Component		Target	Excess over target	Cost per unit (£)	Cost per 100 cows (£)
Calving Interval (days)	425	365	60	2.00	12,000
Failure to Conceive Culling Rate (%)	19	6	13	1000	13,000
Total Cost (£/herd)					25,000
Total Cost (£/cow)					250
Total Cost (p/litre)					3.57

Source: AHDB Dairy PD+

It should also be noted that poor fertility will also lead to increased greenhouse gas emissions per litre of milk.

## Causes of Poor Fertility

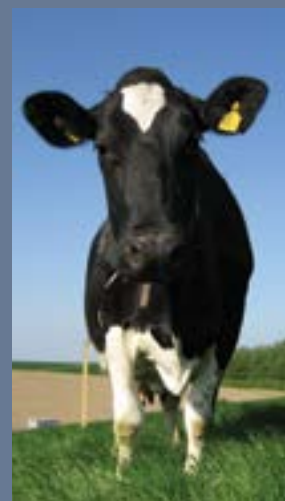
The decline in dairy herd fertility is often attributed to genetic selection for increased milk yields in recent years. However, the issue is more complicated than this and is influenced by a range of interrelated factors, some of which are still poorly understood. These include:

- Energy and protein nutrition (specifically the interaction between nutrition, milk yield and breeding)
- Expanding herd sizes and the pressure this imposes on management and staff
- A range of infectious diseases including Infectious Bovine Rhinotracheitis (IBR), Johne's disease, Bovine Viral Diarrhoea (BVD), Neospora, Campylobacter and Leptospirosis
- Calving-related health problems, including retained foetal membranes and metritis
- Lameness problems, such as digital dermatitis and solar ulcers, which may be also related to housing issues
- The incidence of mastitis
- Management-related factors, such as heat detection and AI technique
- Certain mineral deficiencies

## International dairy cow fertility conference

Because poor fertility is caused by a range of factors, farmers need to identify the key factors limiting fertility on their own farm and seek to address them. Sourcing independent scientific information on how to improve fertility performance can be a challenge. However, in May 2014, many of the world's experts in dairy cow fertility attended an international conference in Westport, Ireland.

The conference entitled "New Science – New Practice" was organised by the British Society of Animal Science (BSAS) and focused entirely on dairy cow fertility. Recognising the importance of this event, AgriSearch tasked their Global Research Officer, Gareth Arnott (Institute for Global Food Security, Queen's University Belfast), to attend the conference and to identify key farmer-friendly take home messages inspired by papers presented at the conference. These have subsequently been summarised in the six short 'chapters' presented within this booklet. I trust that you will find the information presented useful as you strive to improve fertility performance on your farm.



Jason Rankin  
Project Manager  
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# I. HEAT DETECTION IN DAIRY COWS:

## HOW WELL DO NEW TECHNOLOGIES PERFORM?

Accurate oestrus (heat) detection is essential in herds using artificial insemination (AI). Poor heat detection leads to low conception rates and reduced financial performance through decreased milk yields per day of a cow's life, together with increased culling due to failure to conceive. An economic analysis of UK dairy cow data in 2000 estimated that for an average yielding cow (6000 litres), the net cost of one day of delay in conception was £2.41 when conception was delayed from 85 to 100 days post-calving, increasing to £5.02 per day if conception was delayed to between 146 to 175 days post-calving. Indeed, the failure to accurately detect cows in heat has become a major limiting factor for reproductive performance in modern dairy cows. There are a number of reasons why heat detection remains a challenge, including:

- Increases in herd size, resulting in decreased observation time per animal.
- Declines over the past 50 years in the percentage of Holstein dairy cows exhibiting standing heat (estimated to have declined from 80% to 50%), coupled with decreased duration of heat expression (from 18 hours to less than 8 hours).
- Decreased intensity of secondary behavioural signs of heat. An increasing number of cows show no heat signs at all, termed 'silent' heat. For example, recent studies report that between 50% and 94% of first ovulations after calving are 'silent' with no visible signs of heat behaviour in Holstein cows, with figures of between 6% and 50% for second heats after calving, decreasing to between 0 to 35% for the third heat after calving.
- Reduced opportunities for cows to express heat behaviour in housed systems.

Due to the importance of heat detection and the challenges highlighted above, a number of technologies have been developed to assist farmers to identify cows 'on-heat'. While some of these systems are very simple, more recently a new generation of electronic systems that continuously monitor physical activity to predict heat have been developed and marketed to the dairy industry. Table 1.1 provides an overview of the main types of heat detection aids used in the UK at present.

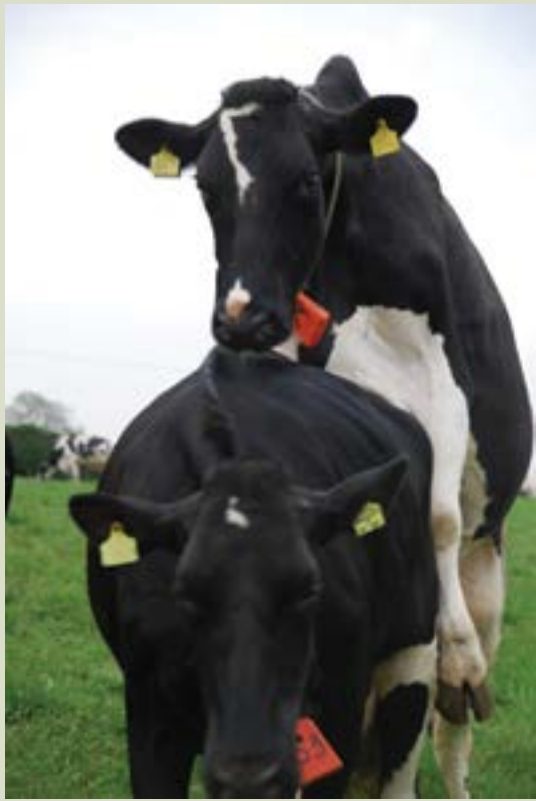
Table 1.1. Heat detection aids used in the UK\*

Heat Detection Aid	Comments
Tailhead mounted detectors (e.g. Estrotect, Kamar)	Range of devices available. Cheap at around £1 per cow. Need to manually check at least daily
Tail paint or wax crayon 'chalks'	Very cheap but labour intensive. Need to top up frequently and observe cows closely for changes. Cow brushes may reduce performance of this heat detection aid
Vasectomised bull with chin ball marker	Present all the time. Marks cows that have been served. Relatively low cost. Disease risks. Don't forget to vaccinate the bull during herd vaccinations.
Pedometers and activity meters	Initial relatively high financial investment. Performance discussed in detail below.
In-line milk progesterone monitoring (e.g. Herd navigator, DeLaval)	High initial financial investment. Identifies cows at various stages of the reproductive cycle, including those that are likely to be coming into heat.

\*Adapted from review by Gordon 2011, In Practice, 33, 542-546.

Given the potential benefits of these technologies for improving reproductive efficiency, there has been a rapid uptake in the use of activity monitoring devices, particularly in the USA and UK. In this article we examine the latest research findings on how well these technologies perform. However, to understand how the technology operates, a brief summary of oestrus behaviour is first presented.





## OESTRUS BEHAVIOUR

Driven by important hormonal mechanisms, a number of physiological and behavioural changes occur as a cow comes into heat. The primary reliable positive sign of true oestrus is standing to be mounted.

Other secondary signs associated with oestrus include:

- Increased activity
- Clear mucus from vulva ('bulling string')
- Chin resting
- Mounting other cows
- Bellowing
- Sniffing the vulva of other cows and the flehmen response (sampling air in a posture with curled back upper lip, head held high, and neck stretched)

While standing to be mounted is the 'textbook' definition of heat, it may only occur in 50% of heat events.

Therefore secondary signs are frequently used as an indication of heat. It is the secondary sign of increased activity that the new generation of electronic 'activity monitors' are designed to detect.

## ACTIVITY MONITORS

A range of activity monitors are currently commercially available. Table 1.2 summarises three of the main types of devices that are available.

Table 1.2. Types of activity monitoring devices

Type of device	How it works	Commercial examples
Pedometer	Fixed to the cows leg and records the number of steps taken over a period of time.	AfiTag (Afikim, Kibbutz Afikim, Israel) Crysta Act+ (Fullwood Ltd, Ellesmere Shropshire, UK)
Neck mounted activity-meter	Records neck movements in all three dimensions	Alpro (DeLaval) Heatime (SCR Engineers Ltd, Netanya, Israel) MooMonitor (DairyMaster, Ireland)
Leg mounted activity-meter	Assesses activity by measuring number of steps taken and also quantifies lying and standing behaviour. Uses 3D accelerometer technology	IceTag3D (IceRobotics Ltd, Edinburgh, UK)

Each of the activity monitoring devices records activity data continuously and transmits this information to a receiver at regular time intervals (e.g. located at the entrance of the milking parlour with Heatime). From the receiver, the data are automatically forwarded to a database in a central computer, or to a mobile phone. The software supplied with each device compares the current activity of each animal with that recorded previously, and uses the differences between these two activity levels to generate a list of cows eligible for insemination.



## HOW WELL DO ACTIVITY MONITORS PERFORM IN HOUSED COWS?

A number of recent studies have examined the effectiveness of activity monitors when cattle are housed (Table 1.3). Two key performance indicators for heat detection aids are listed; efficiency and accuracy. **Efficiency** is a measure of how good the technology is at detecting cows in heat; the higher the percentage the better the technology. However, not all cows detected in heat may actually be in heat (termed false-positives and typically determined by researchers through examination of milk progesterone levels). The **accuracy** measure tells you the percentage of heat detections that are correct (i.e. when the cow is actually in heat).

Table 1.3. Results from studies comparing different heat detection methods in housed dairy cows

Study Location	Detection Method	Efficiency (%) <sup>a</sup>	Accuracy (%) <sup>b</sup>
UK <sup>1</sup>	Scratchcard <sup>c</sup>	35.9	63.9
	Heatmount detector	56.7	61.3
	Farm staff	63.8	86.0
	Neck collar	58.9	93.5
	Leg mounted Pedometer	63.3	73.5
	Neck collar and Farm staff	75.0	91.7
USA <sup>2</sup>	Neck collar	91	95
	Heatmount detector	86	93
The Netherlands <sup>3</sup>	Leg mounted pedometer	81-91 <sup>d</sup>	ND
USA <sup>4</sup>	Leg mounted pedometer	81-89 <sup>d</sup>	ND
The Netherlands <sup>5</sup>	Leg mounted pedometer	79-87 <sup>d</sup>	65-94
Denmark <sup>6</sup>	Neck collar	56-84 <sup>d</sup>	ND

<sup>a</sup> **Efficiency** = number of cows in oestrus detected / number of cows in oestrus x 100

<sup>b</sup> **Accuracy** = number of correct oestrus detections / number of correct + false-positive oestrus detections x 100

<sup>c</sup> Scratchcard is a form of heatmount detector; rubbing the scratchcard during mounting removes a thin film to expose a brightly coloured layer underneath.

<sup>d</sup> Values vary depending on the computer software settings used to define an increase in activity as an oestrus period.

ND, not determined

<sup>1</sup> Holman et al. 2011, Veterinary Record, 169, 47.

<sup>2</sup> Fricke et al. 2014, Animal, 8, 134-143.

<sup>3</sup> De Mol et al. 1997, Livestock Production Science, 48, 219-227.

<sup>4</sup> At-Taras & Spahr 2001, Journal of Dairy Science, 84, 792-798.

<sup>5</sup> Roelofs et al. 2005, Theriogenology, 64, 1690-1703.

<sup>6</sup> Lovendahl & Chagunda 2010, Journal of Dairy Science, 93, 249-259.

- Activity monitors led to high efficiency (average of 81%) and accuracy (average of 89%) of heat detection (Table 3).
- Actual efficiency and accuracy values for activity monitors varied between and within studies depending on how the software was set up. However in studies that compared these devices with other approaches such as heatmount detectors or scratchcards (Studies 1 and 2), equivalent or improved results were shown.
- Unsurprisingly, the efficiency of these devices (neck collars in Study 1) appears to improve when farm staff observations are also used.
- Study 2 also demonstrated an additional important point relating to the problem of silent heats. Of the cows not detected in heat by the activity monitoring system, 35% ovulated (i.e. they had exhibited 'silent' heat).
- 'Silent' heat events are an on-going problem, and these cows will not be detected based on primary or secondary signs of heat when using an activity monitoring system.



HOW WELL DO ACTIVITY MONITORS PERFORM IN GRAZING COWS?

Recent studies have also examined the performance of activity monitoring systems in **pasture-based systems** (Table 1.4).

Table 1.4. Results from studies comparing different heat detection methods in dairy cows at pasture

Study Location	Detection Method	Efficiency (%)	Accuracy (%)
New Zealand <sup>1</sup>	Heatmount detector	91	95
	Neck collar*	60	68
Ireland <sup>2</sup>	Neck collar*	72	68
Australia <sup>3</sup>	Neck collar*	87-94	41-76

\* Activity monitor  
<sup>1</sup> Kamphuis et al. 2012, Journal of Dairy Science, 95, 3045-3056.  
<sup>2</sup> Aungier et al. 2012, Journal of Dairy Science, 95, 2452-2466.  
<sup>3</sup> Hockey et al. 2010, Reproduction in Domestic Animals, 45, e107-e117.

These results suggest that while activity monitoring systems show promise for managing reproduction in grazing-based systems, there is still room for improvement.

TIMING OF AI

Owing to the short lifespan of the ovulated egg in cattle, the interval between AI and ovulation is critical for optimising dairy cow fertility (e.g. am/pm rule when visual heat detection is used). American researchers working with housed dairy cows found that the average interval from AI to ovulation (when inseminating based on heat detection by an activity monitoring system) was 7.9 hours. However, they found considerable variation between individual cows in the AI to ovulation interval (ranging from -12 to 26 hours). For example, 21% of cows received AI between 0 to 12 hours after ovulation, a timing associated with low fertilization rates and embryo quality. As a practical recommendation, the authors advised that farms relying on activity monitoring systems for timing of AI should generate lists of cows eligible for insemination based on the system software and conduct AI twice rather than once daily with the aim of minimizing variation from AI to ovulation.



## IN-LINE MILK SENSOR TECHNOLOGY

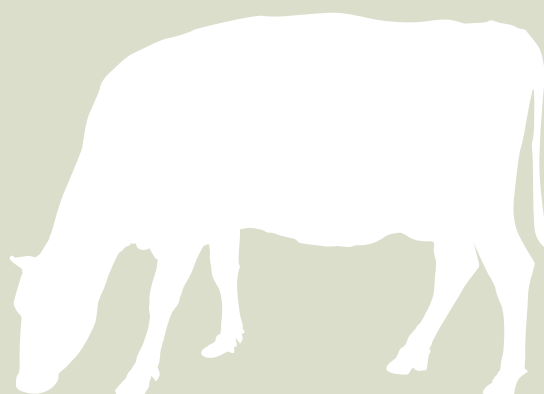
Progesterone is a hormone found in milk and its levels change predictably during the reproductive cycle. It is already possible to measure in-line milk progesterone levels of individual cows at each milking (e.g. Herd Navigator, DeLaval). The in-line technology uses information on milk progesterone to classify cows into three categories; cows not cycling post calving, cows cycling and cows that are potentially pregnant. For cows that are cycling, a heat alert is triggered by the software as soon as the progesterone value drops below a threshold level. However, a decrease in milk progesterone alone cannot accurately predict the timing of ovulation. This is a problem because information on ovulation timing is important for optimal timing of AI. The currently available in-line milk progesterone technology also requires a major initial financial investment. Future research may identify other substances or hormones secreted in milk that can be detected by in-line sensors which will help in identifying the optimum time for AI.

### TAKE HOME MESSAGES:

- Good heat detection can contribute to improved profitability
- The new generation of electronic systems that continuously monitor physical activity to detect heat perform well in housed systems and offer a useful labour saving role to assist farmers.
- Given the cost, this technology is likely to be more attractive for larger herds and under circumstances where farmers are unable to devote the desired amount of time to visual heat detection.
- While the technology shows promise for pasture-based systems, there is still room for improvement.
- The current technology is not fool proof, and therefore is not a substitute for good stockperson skills and investing time in observing cows for signs of heat.
- Currently, research evidence suggests that the best heat detection results are achieved by combining the use of heat detection aids, including the new generation of activity monitors, with visual observation of cows by the farmer.

## Acknowledgements

Fricke P. M., Carvalho P. D., Giordano J. O., Valenza A., Lopes Jr G. & Amundson M. C. 2014. Expression and detection of estrus in dairy cows: the role of new technologies. *Animal*, 8, s1, 134-143.



## 2. FEEDING FOR IMPROVED FERTILITY

Poor dairy cow fertility still represents the most significant production challenge faced by the majority of dairy farmers in Northern Ireland. The average replacement rate currently exceeds 30%, while more than half of cows which are removed from farms are culled due to failure to rebreed. These are otherwise healthy animals. This represents a huge inefficiency, jeopardising the profitability and sustainability of dairy farming.

Below is a summary of the key steps needed to get a cow back in calf, the majority of which are directly or indirectly influenced by nutrition. The series of steps are comparable to links in a chain, and a weak link at any point can cause the whole chain to fail.

### THE FERTILITY CHAIN

- Good dry period management to prepare the cow for calving and lactation
- Body condition score of 2.5 to 3.0 at calving
- Hygienic calving conditions, with cows monitored and assisted where necessary
- Gradual introduction of concentrates into the diet over the first 21 days post calving
- High quality lactation diet balanced for carbohydrates, fibre, protein, minerals and vitamins
- Unrestricted access to food during lactation, through a properly designed feed barrier, with adequate feeding space per cow, to maximise intake. Fresh food offered daily
- Minimise the period of negative energy balance (discussed in detail below)
- Minimise uterine infection
- Freedom from diseases and lameness
- Timely resumption of reproductive cycling
- Good heat expression and detection
- Correct timing of insemination
- Fertilization, embryo development, successful implantation of the embryo, maintenance of pregnancy

### BODY CONDITION SCORE MANAGEMENT

Routine body condition scoring (assessing the fat cover over the back and tail head areas, scored on a thin to fat scale from 1 to 5) is one of the most useful, yet under-used methods for assessing nutritional status and dietary performance on farm. It is a highly effective, cheap and non-invasive monitoring tool. Body condition score is largely determined by the cow's nutritional management. In addition, research has demonstrated that thin cows have poorer fertility than cows at optimum body condition score.

The following targets are generally recognised as being appropriate for dairy cows on grass/grass silage based systems:

- A body condition score of 2.5 – 3 at drying off
- No change in body condition score during the dry period (condition score should be adjusted during late lactation)
- A body condition score of 2.5 – 3 at calving. Cows with a condition score of greater than 3 – 3.5 at calving will have an increased risk of calving difficulties, lower feed intakes, and an increased risk of ketosis / fatty liver
- Maximum of 0.5 unit loss of body condition between calving and peak lactation

As a minimum, cows should be scored at calving, 60 days post-calving, 100 days before drying off, and at drying off. Cows that are identified as having a below target body condition score at 100 days before drying off should be managed so as to gain body condition prior to drying-off. AHDB Dairy have produced a very useful, easy to follow fact sheet and training video on how to body condition score your herd, available to download at <http://dairy.ahdb.org.uk/bcs>.



## DRY COW FEEDING

The question of 'the optimum' dry cow feeding strategy is one which causes much debate, with diverse and often apparently conflicting approaches frequently advocated. One factor which lends confusion to this debate is that much of the research evidence originates in North America, where the main problem faced during the dry-period is often associated with 'over conditioned' ('fat') cows. In contrast, within grassland based systems cows are more at risk of being in a lower than optimum body condition score (thin) at drying off.

In the situation where cows are over conditioned at the start of the dry period, the advice is clear, namely to avoid any further increase in body condition during the dry period. A number of nutritional strategies have been proposed for dealing with these 'fat' cows, including restricting intakes (limiting access to food, or tight grazing), or diluting the energy density of the diet by including straw in the diet. Evidence to support these strategies is limited, and these approaches can be both difficult to manage, and have certain risks. Thus the advice is to avoid cows getting over-fat in the first place, with condition score assessment at 100 days pre drying-off being key to avoiding this problem.

The advice clearly differs for cows which are thin at drying off. An AgriSearch funded study conducted on local dairy farms demonstrated that thin cows (cows with a body condition score of 2.25 or less at calving) have a greater risk of being culled during the first 60 days post calving than cows with a condition score of 2.5 or greater. This was especially true when a forage only diet was offered to these cows during the dry period. The risk of being culled was reduced when these thin cows were offered concentrates for either the entire dry period, or for the last three weeks of the dry period, even though concentrate feeding resulted in no noticeable gain in body condition. While few other studies have specifically examined the effects of dry cow feeding on thin cows, the results of this study suggest that cows which are thin at drying off require special attention, and that benefits are likely to be achieved when these cows are offered a high quality diet containing concentrates. Nevertheless, the primary advice must be to avoid cows being overly thin at the time of drying off, and this can be avoided by condition scoring all cows at approximately 100 days pre drying off. Cows with low body condition scores at that stage should be given special attention in late lactation. Indeed, the management of thin cows in late lactation is an issue which is currently being examined in another AgriSearch funded experiment at AFBI Hillsborough.

Having examined the issues associated with cows which are either overly fat, or overly thin at drying off, let us now consider cows which are at the target body condition score at drying off (2.5 – 3.0). In general, the current advice is to meet but not exceed the cow's energy requirements. In most cases this can be achieved with good quality grass silage, or a moderate quality grass silage plus a small amount of concentrate supplementation. In the large scale on farm study described earlier (1200 cows over two years), supplementing dry cows with 2 – 4 kg of concentrate either for the entire dry period, or for the final three weeks of the dry period (along with good quality silage), resulted in no milk yield or fertility benefits during the subsequent lactation, compared with offering no concentrates. These findings are also supported by recent American research<sup>1</sup> demonstrating that high energy feeding during the dry period was associated with poorer energy balance and poorer reproductive performance after calving, compared to feeding a controlled energy diet.



The American research involved compiling results from seven studies conducted at the University of Illinois involving a total of 408 Holstein cows. Treatments were applied during both the far-off dry period (drying off to three weeks before calving), and the close-up dry period (last three weeks before calving). In each of these phases of the dry period cows received either:

- A controlled-energy diet (less than or equal to 100% of requirement), or a
- High-energy diet (greater than 100% of requirement).

The fertility measure used was ‘days to pregnancy’, and this was significantly shorter for cows fed a controlled-energy diet compared to a high-energy diet during the close-up period, as highlighted in Figure 2.1. Moreover, cows fed high-energy diets during the close-up period lost more body condition in the first six weeks after calving. There was also evidence of improved energy balance in cows fed controlled-energy diets during the far-off period, as they had lower concentrations of circulating fatty acids (an indicator of fat mobilisation), higher concentrations of glucose in the blood, and less evidence of fatty liver, during the first three weeks of lactation compared with cows fed high-energy diets. High levels of fatty acids circulating in the blood during the first week post calving are known to be associated with a greater probability of diseases.

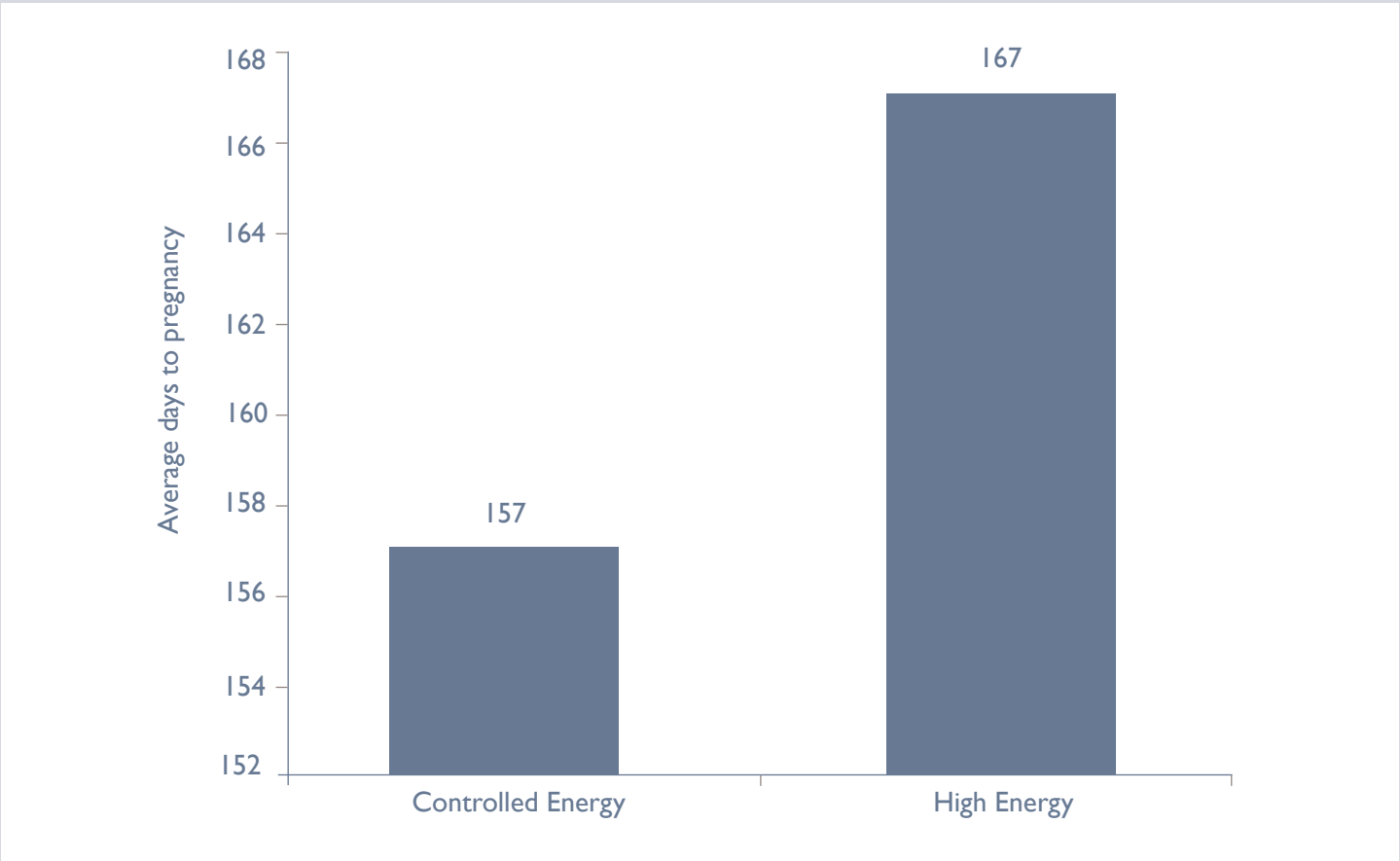


Figure 2.1. Average days to pregnancy for Holstein cows in an American study which were fed either controlled energy or high energy diets during the last three weeks before calving.

While there is still considerable uncertainty about many aspects of dry cow feeding, one issue that is generally recognised as essential is ensuring that dry cows have access to a quality dry cow mineral and vitamin supplement. For many farmers, offering dry cows a small amount of concentrate is one of the most effective means of ensuring all cows have an adequate mineral/vitamin intake. If concentrate is not being fed then other options should be considered. It is also recognised that the drop in intake which occurs in the ‘close-up’ period (i.e. the three weeks pre calving) should be minimised by ensuring that cows have access to a palatable diet. In general, it is also recognised that good cow comfort is important during the dry period, with sufficient dry lying spaces and group changes kept to a minimum to avoid social stress.

## FEEDING THE LACTATING COW

During early lactation higher yielding cows are frequently unable to consume sufficient energy to meet their energy requirements for milk production, resulting in a period of negative energy balance. When cows enter negative energy balance they mobilise body reserves (particularly fat) to meet their energy requirements, and may lose 30 to 40% of the initial fat reserves that were present at calving. When body fat is broken down, fatty acids are produced. These fatty acids are then mainly processed in the liver, with three main mechanisms operating: (1) they can be used to produce energy, (2) they can be diverted to ketone production, and (3) they can be stored in the liver as fat ('fatty liver syndrome'). Some cows adapt poorly to negative energy balance resulting in high levels of fatty acids, low levels of glucose, infiltration of the liver with fat, and a marked increase in ketone production. This is the toxic mix that results in the disease termed ketosis, and this is discussed in detail in another article in this booklet. Up to 50% of dairy cows have some degree of fat accumulation in the liver in the first 4 weeks of lactation. Current estimates suggest that 5 to 10% of cows get severe fatty liver and 30 to 40% have moderate fatty liver after calving.

## HOW DOES NEGATIVE ENERGY BALANCE AFFECT FERTILITY?

Negative energy balance is thought to negatively affect fertility by three main mechanisms:

1. Delayed resumption of reproductive cycling after calving, through effects on hormonal pathways and ovarian function.
2. Negative impacts on the quality, viability and function of the egg that is released and on the corpus luteum (which is necessary to maintain pregnancy).
3. An accumulation of fatty acids within the liver can impair liver function. For example the ability of the liver to 'clear' reproductive and metabolic hormones can be reduced, thus altering the normal signalling to reproductive tissues.

Negative energy balance and fatty liver are associated with poor cow health status, including; uterine diseases (metritis and endometritis), mastitis and left displaced abomasums. Consequently, minimising the duration and extent of negative energy balance in early lactation provides an important nutritional strategy by which to improve fertility.

## FEEDING STRATEGIES TO PROMOTE FERTILITY

As most dairy cows are unable to consume sufficient food to meet their energy requirements in early lactation, it is important to offer a high quality energy dense ration to promote total dry matter and energy intake. While high quality rations start with high quality forages, silage quality within Northern Ireland has unfortunately remained relatively unchanged during the last 20 years! The guidance remains unchanged with regards to silage making – harvesting at the correct stage of growth, rapid wilting, treatment with a proven silage additive, rapid ensiling, adequate rolling to ensure compaction, and sealing to achieve anaerobic conditions rapidly. Most farmers appreciate the potential of high quality forage to improve fertility, with reproductive performance often mirroring forage quality. A renewed focus on grass silage quality is critical! For those who are able to achieve high yields of quality maize (greater than 25% dry matter and greater than 25% starch), the inclusion of maize silage in the diet will also promote total dry matter intakes.

In most scenarios, even when quality forage is available, concentrate feedstuffs are also required to help meet the cows energy requirements. Including concentrates in the diet will promote both total dry matter intake, and increase the nutrient density of the diet. However, research has not always established a clear link between concentrate feed level and cow fertility, possibly because feeding additional concentrates often promotes the production of additional milk. However, the adoption of appropriate concentrate feeding strategies will, in general, help improve energy balance, and consequently help maintain fertility performance.

Concentrate levels should be gradually built up over the first 21 days post calving to avoid the risk of rumen upset, including subacute ruminal acidosis (SARA). There are a number of management strategies to prevent this condition and these are discussed in the next article in this booklet.

In addition to seeking to minimise the extent of negative energy balance experienced, the following practical issues should also be considered when seeking to maximise fertility performance post calving:

- In addition to energy, the diet must also be balanced for protein, fibre, fat and minerals and vitamins.
- Feed should be constantly available to cows, with adequate feeding space per cow. This sounds obvious but is frequently overlooked, particularly with expanding herd sizes. Inadequate feeder space will increase cow competition for access to feed, resulting in aggression and bullying (with heifers being particularly susceptible). Social stress and aggression have direct negative effects on fertility by impairing hormonal mechanisms and will also reduce feed intake. A feed space of >0.6 m per cow is often recommended and it makes sense to provide cows with as much feed space as is practically possible.
- For spring calving herds, where production is based on milk from grazed grass, pasture management is of fundamental importance.

## TAKE HOME MESSAGES:

- Good nutritional management is central to dairy herd fertility, influencing many important steps necessary to get a cow back in calf.
- Body condition score management offers a very useful tool to assess cow nutritional status and dietary performance. The target body condition score is 2.5-3 at calving, with no change during the dry period, and a maximum of 0.5 unit loss of body condition between calving and peak lactation.
- Cows should be managed to achieve the target BCS of 2.5-3 at drying off. This can be achieved by body condition scoring at 100 days before drying off and modifying the management of cows accordingly.
- Dry cow feeding strategy should reflect BCS at drying off.
- Negative energy balance occurs during early lactation with cows mobilising fat reserves to meet the energy demand for milk production. Severe and/or prolonged negative energy balance is associated with impaired fertility and other diseases (ketosis, uterine diseases, mastitis and displaced abomasums).
- Minimising the severity and duration of negative energy balance after calving, by using strategies to promote feed intake, is a key nutritional focus for improving fertility.

## Acknowledgements

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# 3.TARGETING KEY PRODUCTION DISEASES AS A MEANS OF IMPROVING FERTILITY

## KETOSIS

As outlined in Chapter 2, a key nutritional goal is to limit the severity of negative energy balance in early lactation, with strategies for this beginning during the dry period. However, if this is not achieved and negative energy balance is severe and/or prolonged, it will lead to ketosis. This condition occurs when cows adapt poorly to negative energy balance and is characterised by low levels of blood glucose as the ration cannot meet the cows increased energy demand for milk production in early lactation. As a consequence of this energy deficit, body fat reserves are mobilised leading to elevated blood levels of fatty acids, which are converted in the liver to ketone bodies. These produce a characteristic sweet smell on the breath of affected cows that most dairy farmers will be familiar with. There may also be infiltration of the liver with fat, due to the rapid mobilisation of body reserves, and this impairs liver function. Ketosis occurs in two main forms; **clinical** and **sub-clinical**.

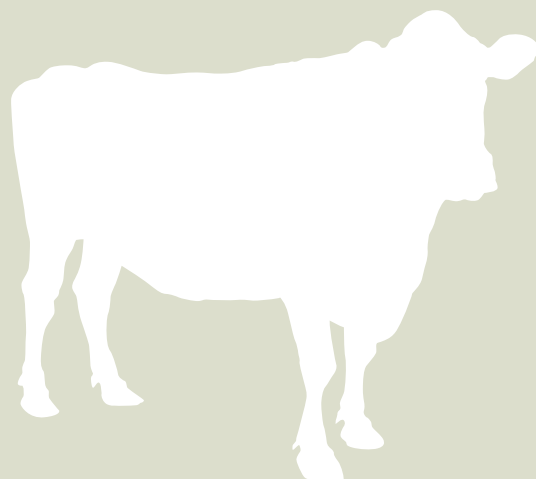
Cases of clinical ketosis usually occur in freshly calved cows (within 6 weeks of calving) and are readily identified by farmers, as affected cows display obvious signs including; lethargy and incoordination, reduced feed intake, reduced milk production, noticeable weight loss, and elevated levels of ketones in all body fluids. However, ketosis also occurs as a sub-clinical condition, with increased levels of ketones in the body **without** the other clinical signs of ketosis. Sub-clinical ketosis can therefore be thought of as a 'hidden' form of the disease. It is estimated that while only 3% of cows in UK dairy herds suffer from clinical ketosis, as many as 30% suffer from the subclinical form of the disease.

Subclinical ketosis is associated with reduced milk yield (estimated to be 41 l litres per lactation) and increased risk of cystic ovaries, left displaced abomasum's, retained foetal membranes, metritis and mastitis. Unsurprisingly, subclinical ketosis can increase calving intervals (by up to 22 days) and leads to increased culling. Consequently the average cost of a case of subclinical ketosis has been estimated to be £690 per cow, rising to £829 per case of clinical ketosis<sup>1</sup>.

Treatment of clinical ketosis is aimed at increasing blood glucose levels and typically involves the use of oral glucose replacements (e.g. propylene glycol) and intravenous glucose injections. However, if clinical cases of ketosis are being observed frequently in a herd, then it is likely that there will be a much larger number of sub-clinical cases which are being missed. Prevention is better than cure and nutritional strategies can be used to prevent clinical and sub-clinical ketosis. These focus on managing the extent of negative energy balance in early lactation, and begin during the dry period.

Managing negative energy balance was discussed in detail in a previous article, which stressed the importance of:

- **Body condition score management:** The target is 2.5-3 at calving, with no change during the dry period, and a maximum of 0.5 units of body condition score loss between calving and peak lactation.
- **Dry cow feeding management** should prepare the cow for the next lactation. The aim is to meet but not exceed requirements.
- **Early lactation feeding management** should be aimed at promoting high intakes of a high quality diet which is balanced for carbohydrates, fibre, protein, fat, minerals and vitamins. High quality feed should always be available to cows, and feed space should be sufficient to allow high intakes to be achieved.





## MILK FEVER

This condition, characterised by low blood calcium levels, is one of the most common production diseases, affecting around 10% of adult dairy cows in the UK<sup>2</sup>. At calving, the production of colostrum causes a rapid increase in demand for calcium. It takes approximately 48 hours for calcium to be released from bone stores, and 24 hours for increased uptake of calcium from the intestine, to meet the increased demand. It is this delayed response to increased calcium demand that leads to milk fever, particularly in older cows during the first 48 hours of lactation.

Calcium is needed for normal nerve and muscle function and this explains the typical clinical signs of weakness and 'downer' cows that are observed. In addition, milk fever reduces food intake, which increases the level of negative energy balance experienced by cows. This results in increased fat mobilisation, predisposing animals to fatty liver and ketosis, with negative knock-on effects in terms of reduced fertility. Furthermore, the reduced feed intake, and reduced muscular activity of the rumen and abomasum, will considerably increase the risk of a displaced abomasum occurring. Reduced muscular tone in the teat end muscle increases the chance of the cow suffering from mastitis. More generally, a low blood calcium level impairs the immune system of cows, limiting their ability to overcome disease challenges encountered in early lactation. The average cost of a case of clinical milk fever has been estimated to be around £210, based on farmer and veterinary surgeon time, treatment costs, and a reduced milk yield<sup>2</sup>.

Milk fever also occurs in a subclinical form in which a cow will have below normal calcium levels, but without the signs that occur with clinical cases. Subclinical milk fever is extremely common, with studies showing around 50% of dairy cows in their second lactation or older, and previously fed "normal" dry cow rations, are likely to have below normal blood calcium levels after calving<sup>3</sup>. These subclinical cases also result in considerable economic losses, recently estimated at around £80 per case<sup>2</sup>.

The principle aim when treating milk fever cases is to restore blood calcium levels to normal quickly and keep levels within a normal range for a prolonged period. Treatment therefore consists of administering calcium salts (e.g. calcium borogluconate) intravenously, subcutaneously or orally. Often a combination of these methods can be used and tailored to cows exhibiting more or less clinical signs of disease. Your vet will be able to advise on the best treatment options for your farm. In addition, there are important preventative strategies that can be used as discussed below.

The main strategy to prevent milk fever is to modify the Dietary Cation Anion Balance (DCAB) of the diet during the late dry period (from three weeks prior to calving).

### Dietary cation anion balance (DCAB)

The DCAB value of a ration or individual feedstuff is calculated from the concentrations of sodium and potassium (the strong cations) relative to sulphate and chloride (the strong anions), and is measured in milliequivalents per kilogram dry matter (mEq/kg DM).

Normally, dairy cow diets result in cows being in a state of so-called metabolic alkalosis (urine pH in lactating cows is >8). This is only a clinical problem in the period prior to calving. High DCAB value rations reduce the rate of calcium uptake from the gut and its release from bone stores. The primary aim of the DCAB method of milk fever control is to acidify the diet and reduce metabolic alkalosis. This is achieved by feeding a diet with a low DCAB (<0mEq/kg DM) which alters the cow's metabolism so that she is more able to mobilise calcium from body reserves, thus reducing the risk of milk fever following calving.

### 'Partial' versus 'full' DCAB approach

The **partial DCAB approach** is now the most commonly used method of milk fever control in the UK. It is based on selecting forages with low DCAB values (potassium concentration is the most important determinant of this), while ensuring adequate magnesium status (as magnesium is also involved in calcium regulation). This involves using grass based forages with the lowest DCAB values (potassium concentrations >2% DM should be avoided) or partially / totally replacing them with low DCAB forages such as straw, maize silage or whole crop cereals.

The **full DCAB approach** involves the addition of anionic salts such as ammonium chloride, magnesium sulphate, and magnesium chloride to the diet. These have strongly negative DCAB values and induce a mild metabolic acidosis, indicated by urine pH values of between 6 and 7. The full DCAB approach has a number of practical disadvantages, a particular problem being that the anionic salts required are unpalatable to cows (they need to be mixed well into the feed or disguised with small amounts of supplementary feeds). Table 3.1 (overleaf) provides a comparison of the two approaches.

Table 3.1 Comparison of partial and full DCAB approaches for the control of milk fever<sup>4</sup>.

	Partial DCAB	Full DCAB
General approach	Decrease forage DCAB base and add 50-100g magnesium chloride to get a Mg concentration of 0.4% DM.	Decrease forage DCAB base and add sufficient anionic salts (typically 100-200g) to get urine pH of 6 to 7
Calcium requirement	No need to manipulate and typically 0.5-0.6% DM	Increased to 1.2% DM to compensate for urinary losses associated with acidification
DCAB range	-50 to +100 mEq/kg DM	-100 to -150 mEq/kg DM
Urine pH	7.8 to 8.1	6 to 7
Monitoring	Urine pH is not accurate at high pH values. Forage DCAB sampling is recommended	Regular urine pH sampling is essential.
Other notes	Very effective and simple if theory is understood and implemented correctly	Anionic salts are unpalatable and can severely depress food intake. Monitoring urine pH regularly can be difficult to achieve

## SUBACUTE RUMINAL ACIDOSIS (SARA)

Subacute ruminal acidosis (SARA) is an increasing problem in high yielding dairy herds offered diets containing high levels of rapidly fermented starch, especially during early lactation. A recent UK study<sup>5</sup>, involving 244 Holstein-Friesian cows that were sampled during routine veterinary visits across 22 dairy farms in Shropshire, Staffordshire, Cheshire and North Wales, diagnosed SARA in 26% of the cows. Such a high level of SARA is costly, with significant financial losses associated with decreased food intake, decreased milk yields, and increased prevalence of associated diseases and disorders. The cost of SARA per affected cow was estimated to be £0.56 per day in a 1999 study<sup>6</sup>, a value that will have increased since then.

SARA is fully dependent on the diet that is being offered, and therefore often occurs as a whole herd problem rather than as an individual cow problem. For example, if large quantities of concentrates are being offered twice daily in-parlour, this causes rumen pH to fall sharply, which then takes time to recover back to normal levels. This period of low pH leads to sub-optimal rumen function, causing a reduction in food intake, pain and indigestion, loose faeces and low milk fat levels. The depression in milk fat levels occurs due to a change in rumen fermentation end products. The depressed food intake that occurs with SARA exacerbates negative energy balance and increases the mobilisation of body fats, and can result in the cow suffering clinical or sub-clinical ketosis, which in turn will have adverse effects on fertility.

### Clinical signs that point towards SARA include;

- Variable herd faecal consistency (some cows with diarrhoea, and others not)
- Poor cow cleanliness in those with diarrhoea, with affected animals tending to tail swish due to the irritation
- Decreased food intake
- Decreased milk yield and butterfat
- Increased incidence of lameness and environmental mastitis
- Poor reproductive performance

However, the only way to conclusively diagnose SARA is by your vet measuring the pH of rumen fluid (with SARA diagnosed if a number of cows have a pH<5.5).

Control of SARA centres on limiting the reduction of rumen pH by controlling the amount and rate of release of rapidly digestible carbohydrate. Table 3.2 (overleaf) outlines a number of control strategies that can be used.

Table 3.2 Control strategies to reduce the risk of subacute ruminal acidosis (SARA)

Control Strategy	Comments
Correct Forage: Concentrate ratio	Forage stimulates salivation (with saliva containing rumen buffers, bicarbonate and phosphate) and rumination. This limits the effects of the acid produced from digestion of concentrate. A maximum concentrate inclusion rate of 60% of the diet (on a dry matter basis) has been suggested to prevent acidosis.
Correct dietary Neutral Detergent Fibre content	Neutral detergent fibre content provides a measure of the cell wall content of feed. This provides a guide to the quantity of fibrous material in the diet which requires chewing (promoting salivation and rumen buffering). A lower limit of 35% neutral detergent fibre is recommended.
Correct total sugar and starch content	An upper limit of 25% sugar and starch (in the total diet) is recommended.
Gradually increase concentrate levels after calving	Recent research conducted by AFBI has demonstrated the benefits of a 'moderate' concentrate build-up strategy, based on a gradual increase in concentrates over the first 21 days of lactation (details provided in AgriSearch booklet 30: The effect of early lactation concentrate build-up strategies on dairy cow performance).
In-Parlour feeding	Limit concentrate intake to a maximum of 4kg per feed (8kg per day) in the milking parlour.
Distribute concentrate feeds correctly	Spreading concentrate feeds throughout the day and/or providing concentrate in smaller meals limits the depression of rumen pH immediately following feeding. This can be achieved with out-of-parlour feeders or the use of a total mixed ration (TMR).
Inclusion of rumen buffers	Rumen buffers, such as sodium bicarbonate, can be included in the diet to buffer the effects of rumen acidosis. These are normally included at approximately 1.5% of the dry matter intake (usually about 150g/cow/day), although the inclusion rate will depend on the product used.
Slower release form of starch	Including lightly crushed or rolled grains in the diet instead of finely ground products leads to slower release of starch over time.
Inclusion of long fibre in the diet	Many farmers include small amounts of long fibre (e.g. 0.5-1kg straw) in the diet to promote rumination and salivation, thus limiting acidosis. This needs to be included in a mixed ration, and offered using a mixer wagon. It needs to be chopped to a length of 5-10 cm to prevent cattle from 'sorting' it from the remainder of the ration. There is however limited research to demonstrate how effective this practice actually is.
Use of transition rations	Feeding a transition ration to cows during the three weeks before calving allows the rumen to adapt to the ration type that will be fed in lactation.

## TAKE HOME MESSAGES:

- Ketosis, milk fever, and subacute ruminal acidosis (SARA) can all have a negative effect on milk production and fertility performance.
- Ketosis occurs when cows adapt poorly to negative energy balance and can occur in a clinical or sub-clinical form, with the latter typically not detected by farmers. Prevention focuses on nutritional strategies to control negative energy balance in early lactation. These strategies begin in the dry period and are aimed at promoting feed intake after calving.
- Milk fever negatively affects the energy status and subsequent fertility of cows. Prevention of milk fever can be achieved by modifying the Dietary Cation Anion Balance (DCAB) using either a partial or full DCAB approach.
- Following calving, the switch to a high energy lactation ration can lead to SARA. Prevention of SARA centres on feeding strategies to limit the fall in rumen pH by controlling the amount and rate of release of rapidly digestible carbohydrate.
- The adoption of nutritional strategies to prevent ketosis, milk fever, and subacute ruminal acidosis (SARA) can have significant financial benefits in terms of improved production and fertility performance.

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# 4. DEALING WITH METRITIS AND ENDOMETRITIS

During the two to three weeks following calving, all dairy cows have some level of bacterial contamination of the uterus. In many dairy cows this contamination is resolved by the cow's own immune responses and by normal changes in the uterus. However, in some cows, the growth of disease-causing bacteria may overcome the animal's defences, resulting in reproductive disease. Farmers normally refer to the resulting infections as 'dirty calf bed', 'calf bed infection', or 'whites'. The negative effects of these infections often go far beyond the bad smell.

**Metritis** is a condition that typically occurs 3 to 9 days after calving, although it can be diagnosed up to three weeks following calving, and affects 5 to 20% of dairy cows. It is characterised by a smelly, watery, red-brown uterine discharge, and a clinically sick cow with decreased milk yield, dullness and fever. **Endometritis** occurs more than three weeks after calving, and can be present in either a clinical or subclinical form. Clinical endometritis refers to the presence of a purulent discharge (pus) from the uterus, which is usually detected in the vagina, and typically affects 15% to 20% of cows four to five weeks after calving. Subclinical endometritis is inflammation of the uterus with no discharge, and has been found to affect 30% to 50% of cows. With both clinical and subclinical endometritis, the cow will otherwise be well, which is in contrast to metritis where she will be obviously ill. Furthermore, a cow with metritis will be more likely to go on to develop endometritis (risk factors detailed in table 8 below). However, it is also the case that endometritis can develop without a cow having previously had metritis.

### What effect do these conditions have?

Uterine diseases are associated with reduced reproductive performance and milk yield as summarised in Table 4.1 below. They therefore have a direct detrimental effect on key farm performance indicators. This should serve to highlight the gains to be made by taking precautions to minimise the incidence of these conditions on your farm.

Table 4.1 Summary of the negative impacts of uterine disease on reproductive performance and milk yield (numbers are given where possible, based on the scientific literature).

Impacts of Uterine Disease	
Metritis	Clinical Endometritis
Increased interval from calving to first service	Increased interval from calving to first service
Increased days-open (by 20 days)	Increased days-open (by 32 days)
Decreased likelihood of pregnancy	Decreased likelihood of pregnancy in first half of lactation (31% less likely to be pregnant by 150 days in milk)
Decreased food intake	Increased pregnancy empty rate (by 16%)
Increased risk of culling	Increased pregnancy loss (e.g. 30% vs 9% for healthy cows between day 32 to 60 of pregnancy)
Decreased milk yield (can be by as much as 2650 kg over a full lactation)	Increased risk of culling (1.7 times more likely)

In addition to the above negative impacts of clinical uterine disease, recent research has highlighted important negative effects of subclinical endometritis. Nine surveys, involving a total of 4418 cows in 67 herds, found that, on average, 32% of cows had subclinical endometritis. The average number of days-to-pregnancy in cows with and without subclinical endometritis is presented in Figure 4.2 overleaf:

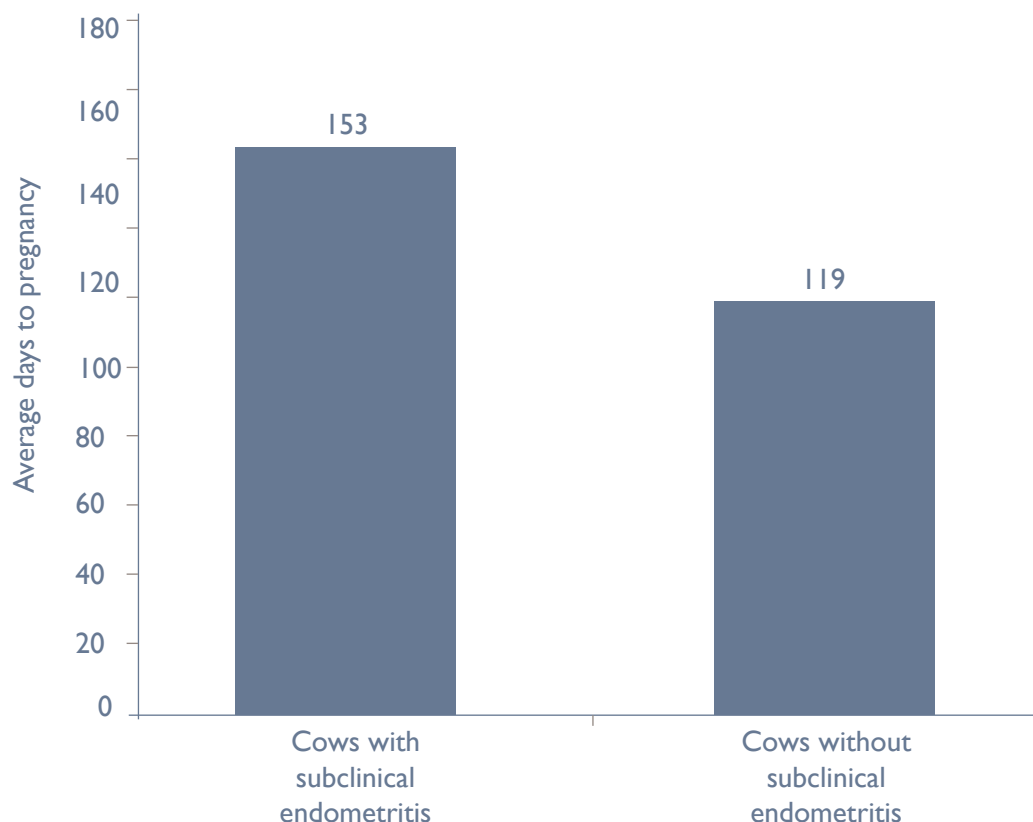


Figure 4.2 Average days-to-pregnancy in cows with and without subclinical endometritis

The data above clearly demonstrate that cows with evidence of subclinical endometritis took significantly longer to become pregnant. Furthermore, studies have shown that in those cases where signs of clinical disease are also present (i.e. purulent discharge in the vagina), it takes even longer to become pregnant (e.g. an increase of 63 days has been reported). In other words, both clinical and subclinical endometritis can act independently to have an ‘additive’ adverse effect on reproductive performance.

## COSTS OF UTERINE DISEASE

The financial losses associated with uterine infection can be attributed to the costs of treatment, reduced milk yields, and infertility. In the UK, the direct costs of treatment and reduced milk yield of a cow with uterine disease were estimated to be approximately £72 per cow in 2002. The indirect costs of a longer calving interval, increased culling rate, extra inseminations and lower heat expression were estimated at £80 per cow, giving a total of £152 per animal. This cost will have increased considerably since then.

## RISK FACTORS AND PREVENTION

An understanding of the risk factors is key to reducing these problems, and these are listed in Table 4.3.

Table 4.3 Risk factors associated with metritis and endometritis (both clinical and subclinical)

Metritis	Clinical Endometritis	Subclinical Endometritis
Calving difficulties	Calving difficulties	Metritis
Retained placenta	Retained placenta	Low body condition at calving
Severe negative energy balance	Severe negative energy balance	Severe negative energy balance
Lower feed intake prepartum and postpartum	Twins, stillborn or male calf	Ketosis postpartum
	Metritis	
	Ketosis postpartum	
	Urovagina (urine pooling in the vagina) at diagnosis	

While work into vaccine development is ongoing, there are some practical steps that farmers can take to help prevent these diseases:

- Maintain good hygiene at calving including the use of disposable gloves and clean, well maintained equipment.
- Calving aids must be cleaned and disinfected between calvings since they come into direct contact with the cow's hindquarters, having the potential to introduce infection into the uterus.
- Calving ropes are usually not adequately cleaned and disinfected between calvings. It is recommended that calving ropes be cleaned of all gross debris and dirt after use and then left in a veterinary disinfectant for 10-15 minutes, dried, and then stored in a clean polythene bag until next used.
- The calving pen should be clean, dry and spacious with adequate ventilation.
- Poor calving assistance increases the level of bacterial infection during calving. Only those skilled in calving should assist cows, and veterinary attention should be sought promptly for difficult cases.
- Prompt disposal of all cleansings from the calving area is also advised.
- Minimise incidence of difficult calving by using easy calving sires and ensure cows are not overly fat at calving.
- Good transition cow management: includes feeding a dry cow mineral and an appropriate pre-calving diet, and minimising the extent of negative energy balance experienced by cows post calving.

## DETECTION AND TREATMENT

Early detection of metritis is important, with practical identification based on at least two of the following indicators: smelly discharge, fever and signs of general illness (dullness, decreased intake, decreased milk yield). Routine, systematic screening of fresh cows is suggested as a useful procedure to detect health problems. With clinical endometritis, often referred to as 'whites', diagnosis is based on examination of the vaginal discharge.

Metritis treatment is currently based on administration of systemic antibiotics, with anti-inflammatory drugs also often used to provide additional supportive therapy. For clinical endometritis the mainstay treatments are intrauterine (IU) infusion of cephalosporin antibiotic (often called a wash-out) and hormonal therapy with prostaglandin. However, recent and on-going research is highlighting that current treatments are often not as effective as would be desirable, both in terms of clinical cure and effect on subsequent reproductive performance. The development of improved treatments is an active research area and your vet will be able to advise on the best treatment options as our understanding of these conditions continues to improve.

### TAKE HOME MESSAGES:

- Metritis and endometritis have significant negative effects on the reproductive performance and milk yield of dairy cows.
- There is increasing evidence that some antibiotic and hormonal treatments have limited effectiveness – this highlights that greater emphasis needs to be placed on prevention.
- Preventative measures aimed at avoidance of difficult calvings, maintenance of a hygienic calving environment, and good transition cow management are important in this respect.

## Acknowledgements

LeBlanc, S. J. 2014. Reproductive tract inflammatory disease in postpartum dairy cows. *Animal*, 8, s1, 54-63.



## 5. BREEDING FOR FERTILITY: THE ROLE OF GENETICS AND GENOMICS IN REPRODUCTIVE PERFORMANCE

Achieving good reproductive performance is of fundamental importance to the profitability and sustainability of dairy production systems. However, with infertility the most common cause of culling on UK dairy farms, achieving improved fertility performance is one of the most significant challenges facing the industry at present. For example, it was recently estimated that a typical 100-cow dairy herd (7000-litre average) was losing 3.57p/litre, £250/cow and £25,000/year through failing to achieve recommended fertility targets.

Dairy cow fertility has been declining for decades. For example, in the early 1980's the average calving interval for the UK dairy herd was 384 days, with a 55% first service pregnancy rate. By 2010 these figures had fallen to 425 days and 42%, respectively. Key to this decline was the dairy industry's previous breeding goals which focussed primarily on selection for high milk production levels, which for the Holstein breed resulted in annual per cow milk yields increasing from approximately 5000 kg in the 1980's to over 8000 kg today. There is now overwhelming scientific evidence that a breeding programme focussed solely on increasing genetic merit for milk yield will reduce dairy cow fertility. For example, if a breeding programme focusing solely on milk yield results in an increase in genetic merit for annual milk yield of approximately 1000 kg milk/cow, calving interval would be expected to increase by between 5 and 10 days.

Using the latest research findings, this article will explain how new genetic selection indexes that include fertility traits, as well as other important functional traits, are being used to successfully halt the decline in dairy cow fertility. The genomic revolution in dairy cow breeding, together with future possibilities, will also be explained.



## WHAT IS MEANT BY GENETICS AND GENOMICS?

You will not be alone if you get confused as to what these terms actually mean! A gene is a basic unit of heredity, consisting of a sequence of DNA within animals' cells, and 'coding' for a particular trait to take a particular form. Genetics is the study of the mechanisms by which genes are passed on to the next generation, as well as the process of examining differences between individual cows in traits and characteristics that we are interested in. In the case of a dairy cow, a genetic index (often known as a proof) provides a measure of an animal's ability to pass genes for particular traits (e.g. milk yield) on to the next generation. A value is given for the expected improvement in offspring performance and this can then be compared against other animals in the population. You will be familiar with genetic indexes for traits such as milk yield, fat and protein %, and fat and protein yield. However, modern genetic indexes now also include a number of important functional traits which seek to improve overall farm profitability, rather than productivity alone. For example, the current UK selection index, the Profitable Lifetime Index (£PLI), brings together information from a variety of traits to produce a single figure. The traits included in £PLI are related to production, fertility, lifespan, udder health, feet and legs, calving ease, and maintenance.

A traditional genetic index is calculated using large amounts of information from a variety of sources, including milk recording organisations and breed societies. AHDB Dairy have recently produced an excellent guide to understanding genetic indexes for farmers (available to download or order at <http://dairy.ahdb.org.uk/resources-library/technical-information/breeding-genetics/breeding-briefs/>) that explains in detail how genetic indexes are produced and what they mean.

For a bull, the most important component of his proof is his daughters' performance. However, the obvious downside of calculating a 'traditional' bull proof is the time involved, taking around 5 years from the time the bull is born, until sufficient information is available on the milking performance of his daughters to provide a proof that is approximately 85% reliable. This is where the field of genomics offers huge scope. Genomics is defined as the study of gene structure, arrangement, regulation and expression. The process of how genomic selection works was first described in 2001, with the dairy industry beginning to adopt genomic selection technology around 2006. This is a new and rapidly evolving field of scientific and commercial interest. The dairy breeding industry currently uses a combination of traditional genetic and novel genomic technologies to produce genetic indexes.

## HOW GENOMICS WORKS

A genomic evaluation is produced from information obtained from an animal's own DNA, with DNA samples normally obtained from a sample of a calf's hair or tissue. The DNA is then examined using sophisticated technology and computer programmes that compare the DNA sequence from the animal of interest to that of a reference population of previously genotyped cattle. In the reference population, the effect of particular DNA patterns on the traits of interest (e.g. milk yield, fertility and health measures) has previously been examined and quantified. Thus by comparing the DNA profile of the candidate animal with that of the reference population you can then estimate its genetic merit based solely on its DNA information. Genomic information enables the identification and selection of elite breeding stock at birth, and this provides a huge advantage over traditional proofs which rely on information on a bull's daughters becoming available. Genomic selection therefore provides an opportunity to increase the rate of genetic improvement across the industry as a whole.

## THE RELIABILITY PROBLEM

If we now have access to genomic selection tools, why bother with conventional progeny-testing systems? The short answer is reliability! For production traits, current reliabilities achieved for genomic evaluations on young bulls are around 65-70%. This compares with a Pedigree Index based only on parent information that is 30-40% reliable, while at the other extreme, a traditional proof for a bull based on the performance of daughters in several hundred herds could have a reliability of up to 99%. Thus genomic indexes for production traits have reliabilities somewhere between the two more traditional measures. That said, as a genomically selected sire accumulates daughter information, the reliability of the genetic index will increase with time. The AHDB Dairy guide cited previously has some excellent practical advice on using genomic indexes.

Unfortunately, genomic evaluations of fertility traits are currently less reliable than those for production traits due to fertility traits having a low heritability (explained below). However, as the number of sires being genotyped increase, and as genotyping technology continues to develop, the reliability of genomic evaluations for a variety of traits (including fertility) will continue to improve.

# THE GENETICS OF FERTILITY

The speed with which genetic improvements in fertility can be made is influenced by the heritability of the fertility trait in question. Heritability is an estimate of the degree to which a trait is passed to the next generation, and is expressed on a scale of 0 to 100%. For example, while milk yield is highly heritable (55%), fertility traits have a relatively low heritability (around 3%, see Table 5.1). Although rapid progress can be made when selecting for highly heritable traits, it is still possible to make genetic progress when selecting for traits of low heritability (e.g. fertility). In practical terms, progress can be made by using selection indexes which incorporate these fertility traits, for example, £PLI.

Table 5.1 Heritability estimates for fertility traits in Holstein-Friesian dairy cattle

Fertility Trait	Heritability
Calving interval	3.4
Non-return rate	2.7
Calving to conception interval ('days open')	3.8
Interval from calving to first service	5.2
Interval from first to last insemination	3.2
Number of services per pregnancy	2.1
Pregnancy to first service	2.3

## POTENTIAL FUTURE REPRODUCTIVE TRAITS

Given the low heritability of commonly used fertility traits, together with the difficulties in obtaining accurate records for some of these traits, the heritability of alternative reproductive traits is currently being examined. For example, the interval from calving to commencement of cycling (luteal activity) has been proposed as a genetic indicator of fertility, with results from four studies suggesting a heritability of 15%. This interval can be determined by measuring milk progesterone levels, something that could not be undertaken routinely in the past. However, technological advances in in-line sensors and in robotic milking systems mean that this information will become increasingly accessible and it may be possible to include this information in breeding programmes in the future.

A recent Danish study examined another potential genetic indicator of fertility, namely 'days to first heat' recorded using activity meters. This was found to have a heritability of 12 to 18%. This value is considerably higher than many currently used measures, and it is possible that in the future activity meter based fertility traits may provide valuable information to dairy breeding programs. Furthermore, detailed information on additional reproductive traits could become widely available with computerised record keeping. For example, veterinary records of fertility-related diseases (e.g. metritis, retained placenta, cystic ovaries), that have previously been shown to be heritable, could be used in future breeding programmes.



## HALTING THE DECLINE IN FERTILITY

Figure 5.1 shows the genetic trend for reproductive performance in the UK, with genetic merit and performance for calving interval deteriorating (increasing) until around 2009. This decline in fertility performance coincided with a period where selection was focussed primarily on increasing milk production. Thankfully, in recent years the industry has been addressing this issue, and this is clearly visible in Figure 5.1 by a trend for improvements in genetic merit and performance for calving interval since 2009 (reflected in the figure as the downward sloping lines). This is undoubtedly due to the increasing adoption of £PLI

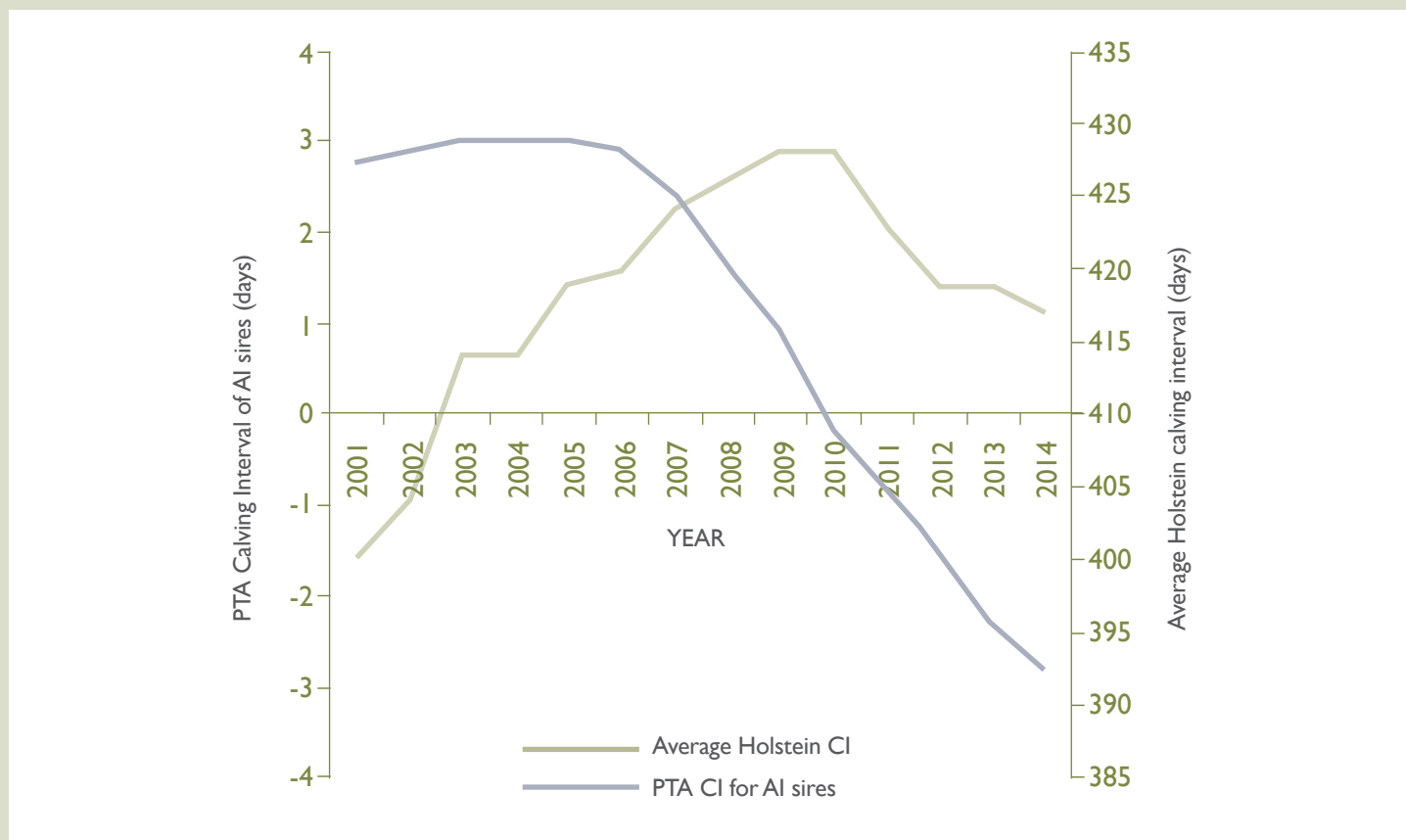


Figure 5.1 The genetic trend for reproductive performance in the UK. The blue line plots the calving interval PTA for AI sires (expressed as the predicted change (days) in genetic merit for calving interval), while the green line plots the average calving interval shown by Holstein cows during this period of time.

## HOW PLI IS IMPROVING DAIRY COW FERTILITY IN THE UK

£PLI is a within-breed genetic ranking index that incorporates a number of important production and functional traits. The figure below outlines the emphasis placed on each of the traits that are included in the £PLI calculation. The fertility index of £PLI is calculated mainly based on the combination of calving interval and non-return rate at 56 days. The £PLI value that is published for a particular bull (see <http://dairy.ahdb.org.uk/resources-library/technical-information/breeding-genetics/£pli-factsheet/> and <http://dairy.ahdb.org.uk/resources-library/technical-information/breeding-genetics/£sci-factsheet/>) represents the additional profit expected from each of his milking daughters over her lifetime, compared to the daughters of an average bull of £0 PLI.

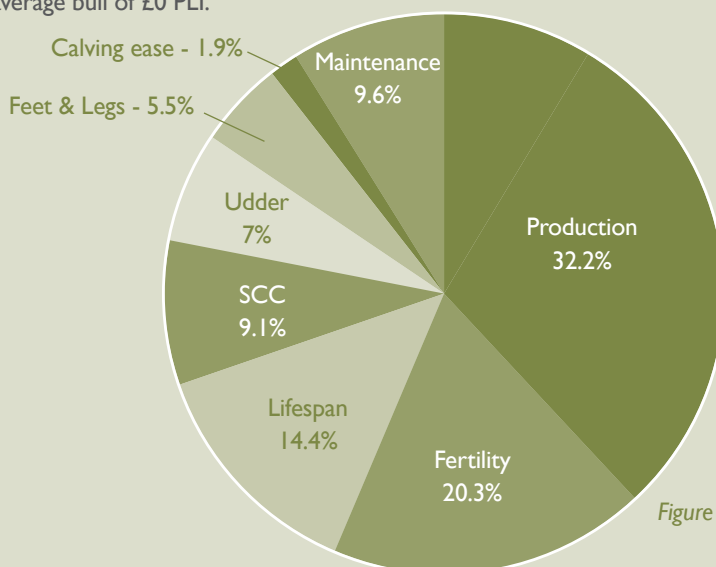


Figure 5.2 Emphasis of traits included in PLI

A recent comparison of selection on the basis of PIN (with 100% emphasis on production performance) or on £PLI (where emphasis on production, reproduction and other fitness traits was 45.2, 18.5 and 36.3%, respectively) found that use of £PLI resulted in an 18% improvement in economic response (per cow per year) compared to selection on PIN alone. This extra profit was achieved even with a reduction in the genetic gain for the yield traits due to an improvement in lifespan and a decrease in the genetic decline of health and reproductive performance. As expected, the production only index resulted in a decline in fertility, with calving interval predicted to increase by 0.64 days per cow per year compared with 0.37 days when selecting with £PLI. It is worth noting that the PLI used in this calculation has since been updated (AHDB Dairy 2014) to place an even greater emphasis on fertility (20.3%) meaning that the current selection index should result in greater fertility improvements.

### LOOKING TO THE FUTURE

The genomic revolution in dairy cattle breeding will continue to evolve. At present, the reliability of genomic indexes is poor for low heritability traits such as fertility. Going forward a number of methods will be used to address this issue and increase the accuracy of genomic predictions. These include; enlarging the size of the reference population (including genotyping females), improvements in DNA sequencing technology and in the accuracy of calculations used to produce the index.

Genomics technology is also identifying genes that have particularly influential effects on performance and reproduction. For example, a number of genetic defects associated with embryonic death and stillbirth have already been identified (see Table 5.2). These conditions are caused by recessive genes which means they will only be expressed when two animals which are both carriers of the defective gene are mated. Thus matings between carrier parents should be avoided to prevent any risk of the genetic defect being expressed. At present, all AI sires are tested for a number of defective genes to identify carriers. The list of genetic defects that can be tested will continue to grow in the future.

Table 5.2 Example of genetic defects that can now be detected using genomics

Genetic defect	Description
Complex Vertebral Malformation (CVM)	Causes stillbirths, or more commonly abortion, or foetal re-absorption before 260 days of gestation
Brachyspina (BY)	Causes abortion and stillbirth, shortened spinal cord, long legs, and abnormal organs
Fertility Haplotypes (e.g. HH1)	Causes lower fertility due to early embryonic death or abortions

Genomics can also help address the problem of inbreeding in the dairy industry. Inbreeding occurs when related animals are mated to each other; and when inbreeding levels become excessive, significant losses in production, fertility, lifespan and general vigour occur. Unfortunately, the rate of inbreeding in most dairy populations is increasing at between +0.10% to +0.25% per year. While pedigree relationships have traditionally been used to control inbreeding in mating plans, genomic mating plans can be used instead. The advantage of basing mating plans on the actual genotype of animals is that it provides a more accurate estimate of the true relationships among animals, including eliminating errors that can occur in recorded pedigrees. Mating plans based on genomic information have recently been developed and in the future will contribute to controlling the inbreeding problem.

Finally, this article has highlighted the opposing relationship between genetic merit for milk production and fertility such that on average, when selecting for milk production, fertility declines. However, this relationship is not absolute and there are animals within the population that have high milk production and good fertility. With current and on-going improvements in genetic and genomic technology it should be possible to continue reversing the downward trend in fertility and achieve genetic gains in reproductive performance without compromising production.

### Acknowledgements

Berry, D. P., Wall, E. & Pryce, J. E. 2014. Genetics and genomics of reproductive performance in dairy and beef cattle. *Animal*, 8, s1, 105-121.



## 6. SEXED SEMEN: IS IT RIGHT FOR YOUR FARM?

A wish list for the dairy industry would include the ability to select the sex of calves at service, rather than relying on a 50:50 probability of getting a calf of the desired sex. In particular, this would create an opportunity to produce heifer calves from the 'best' animals in a herd for use as replacements, while allowing the 'poorer' animals to be bred to a beef sire. This is the prize offered by breeding companies selling sexed semen. This article examines the semen sexing industry, and outlines the benefits, as well as limitations, of the technology. Using recent research findings, the article also outlines the most appropriate scenarios in which to use sexed semen for the best economic return.

Cogent, using technology that was developed in the US, were the first breeding company to offer sexed semen in the UK. The first calves produced using sexed semen were born in the UK in 1999, and since then a number of other AI companies have adopted the technology.



### HOW THE TECHNOLOGY WORKS

Sperm cells are either X-sperm, which produce female offspring, or Y-sperm that produce male offspring. Bovine X-sperm have about 4% more DNA than Y-sperm, and this key difference allows them to be separated. A DNA binding dye is added to the sperm, and then each sperm is passed through a laser beam in single file which enables X- and Y-sperm to be identified. A positive or negative charge is then applied which allows the X- and Y-sperm to be sorted into separate collection chambers. The result is a container of X-sperm (female producing) and Y-sperm (male producing) which can then be frozen for AI use.

The basic technology is not new, being initially developed in US research labs in the 1980s. However, since then there have been numerous technological advances to increase the efficiency of sperm sorting. The equipment currently in use is impressive in speed and accuracy. However, this comes at a price and is the principal reason that sexed semen straws are more expensive than conventional semen straws. In addition, there are a number of limitations to the process, as follows:

1. **Accuracy.** The technology currently in use is 90% accurate. This means that with a female sexed semen straw there is still a 10% chance of producing a bull calf.
2. **Sperm wastage and limits on sorting capacity.** There are physical limits to how many sperm can be sorted accurately, with current technology able to sort approximately 32,000 sperm per second. However, after removal of dead and dying sperm and sperm which are not in the correct position for evaluation, and other technical issues, the number of sex sorted sperm produced is considerably less, at approximately 16,000 per second. With these limits to sorting capacity, together with the costs of the equipment involved, fewer sperm are used in sexed semen straws compared to conventional straws. At present, sexed semen straws contain about 2 million sperm, whereas conventional semen straws contain 10 to 20 million sperm.
3. **Not used for the highest genetic merit bulls.** The fact that current sorting procedures incur significant levels of sperm wastage means that the semen of the highest genetic merit sires is typically not sexed because these bulls are in high demand, and therefore it is not financially attractive for breeding companies to produce sexed semen from them.

## FERTILITY WITH SEXED SEMEN

The main disadvantage of using sexed semen is decreased fertility. There are two main reasons why fertility with sexed semen is lower than with conventional semen, namely fewer sperm per straw with sexed semen, and damage to sperm during the sorting process. Research studies (summarised in Table 6.1 below) have found that conception rates with frozen-thawed sexed semen are typically about 70% to 80% of the conception rates achieved with frozen-thawed conventional semen in both maiden heifers and lactating cows.

Table 6.1 A comparison of conception rates achieved with sexed and conventional semen, from recently published large scale studies<sup>1</sup>.

Year of study	Type of animal inseminated	Sexed semen conception rate (%)	Conventional semen conception rate (%)	Sexed semen conception rate, as % of conventional
Study 1, 2011	Maiden heifers	38	55	69
Study 2, 2010	Maiden heifers	44	23	61
	Lactating cows	32	72	72
Study 3, 2009	Maiden heifers	45	56	80
Study 4, 2010	Maiden heifers	41	26	56
	Lactating cows	32	73	81
Study 5, 2010	Maiden heifers	40	52	77
Average (studies 1-5)	Maiden heifers	42	56	75
	Lactating cows	25	32	78

Conception rate = the proportion of animals conceiving to a given insemination.

More recently, an Irish study<sup>1</sup> found conception rates with sexed semen to be approximately 87% of those achieved with conventional semen in both heifers and lactating cows. Furthermore, this study demonstrated that sexed semen can improve the profitability of seasonal spring calving dairy systems. The lower fertility associated with sexed semen has traditionally been viewed as a barrier to uptake of the technology within spring calving systems.

There is evidence that the reduction in fertility due to the sexing process is not consistent across sires, with some bulls maintaining better fertility with sexed semen than others. Thus in the future it may be possible to develop a diagnostic test that would allow sires that are better suited to the sexing process to be identified, thereby improving the relative performance of sexed semen compared with conventional semen. However, such a test has yet to be successfully developed.

## RECOMMENDED USES AND BENEFITS OF SEXED SEMEN

Currently, the main use of sexed semen is on dairy heifers, with the aim of producing heifer calves for use as herd replacements, for herd expansion, and for sale of surplus heifers. The strategy of using sexed semen on maiden heifers is advised on financial grounds, as these are normally more fertile than lactating dairy cows. This strategy also has a number of additional benefits:

- **Fewer calving difficulties:** Heifers giving birth to female calves are less likely to have calving difficulties compared to when giving birth to heavier male calves. This is useful because cows with difficult calvings have an increased risk of being culled, the calf is more likely to die, production and fertility may be reduced during the subsequent lactation, and veterinary costs may be higher.
- **Improved biosecurity:** The use of sexed semen enables all replacement stock to be generated on-farm, avoiding the need to buy in stock (and associated disease risks) from external sources.
- **Increased rate of genetic gain:** Herd replacements can be bred from only the best heifers (and best cows) enabling more rapid herd genetic progress. In addition, if a breeding programme has focused on continual genetic improvement, on average, the youngest animals in the herd are the best genetically, so calves born from heifers are ideal replacements. However, one factor that limits a greater rate of genetic improvement is the fact that the highest genetic merit bulls are typically not used for sexed semen production at present (as mentioned above). As the technology continues to improve (which it will) it is likely that sexed semen from the highest genetic merit bulls will become increasingly available.
- **Improved beef production from the dairy herd:** Using sexed semen enables the number of replacement heifers required to maintain herd size to be produced from a smaller proportion of the herd. In addition, fewer unwanted dairy bull calves will be produced. The remainder of the herd can then be bred to beef sires, providing an opportunity to increase income from the sale of cross-bred calves (or finished cattle) for beef production.

## POTENTIAL FINANCIAL BENEFITS OF USING SEXED SEMEN

Table 6.2 below demonstrates the potential financial benefits of using sexed semen on heifers, compared with conventional semen use. The parameters used for the calculation are listed below the table. This demonstrates a potential 20% financial gain when using sexed semen on heifers compared to using conventional semen.

Table 6.2 Potential financial benefits of sexed semen use on heifers in a 100 cow dairy herd

	Herd using sexed semen on heifers (with 90% of calves born being heifers)	Herd using conventional semen on all animals (with 50% of calves born being heifers)
<b>AI Costs</b>		
Maiden heifers	28 at 2.5 straws / heifer = £1890	28 at 1.8 straws / heifer = £1109
Cows: conventional Holstein/Friesian semen	10 at 3.1 straws / cow = £682	35 at 3.1 straws / cow = £2387
Cows: conventional beef semen	75 at 3.1 straws / cow = £1395	50 at 3.1 straws / cow = £930
Total semen costs	£3967 / herd / year	£4426 / herd / year
<b>Value of calves born</b>		
Holstein/Friesian heifer calves at £250 / calf	30 x 250 = £7500	30 x 250 = £7500
Holstein/Friesian bull calves at £80 / calf	5 x 80 = £400	30 x 80 = £2400
Beef cross calves at £175 / calf	75 x 175 = £13125	50 x 175 = £8750
Total calf value	£21025	£18650
Calf value – semen costs	£17058	£14224
Financial gain by using sexed semen	£2834	

### Calculation details:

- The example calculation is given for a 100 cow herd, with a target replacement rate of 25%, aiming for 30 heifer calves born, with 28 maiden heifers available for breeding.
- 28 maiden heifers and 85 cows are bred to calve the following year, with the remaining stock destined for “normal” culling.
- The calculation assumes that maiden heifers / cows are bred to AI with the following conception rates to service:
  - Sexed semen heifers = 40% (equates to 2.5 straws/heifer)
  - Conventional semen heifers = 57% (equates to 1.8 straws/heifer)
  - Conventional semen cows = 32% (equates to 3.1 straws/cow)
- The calculation assumes the following costs:
  - Holstein/Friesian sexed semen = £27 per straw
  - Holstein/Friesian conventional semen = £22 per straw
  - Conventional beef semen = £6 per straw
- The calculation assumes the following calf values:
  - Holstein/Friesian heifer calves = £250
  - Holstein/Friesian bull calves = £80
  - Beef cross calves = £175

## DOES SEXED SEMEN HAVE A ROLE ON YOUR FARM?

Be aware of the limitations that exist with sexed semen and decide if it offers a useful tool for your farm. Points to consider include:

- The main advised use of sexed semen is to breed dairy heifers to produce heifer calves for herd replacements.
- Widespread use of sexed semen on a large number of cows in your herd is currently not recommended due to the fertility issues discussed previously.
- With sexed semen there is less margin for error in the insemination process. Careful attention should be paid to semen handling, thawing and insemination. AHDB Dairy have produced a useful practical guide to manage semen correctly, available at (<http://dairy.ahdb.org.uk/resources-library/technical-information/breeding-genetics/breedingplus-section-5-managing-your-semen>).
- Sexed semen should only be used on healthy animals. Avoid its use on animals with uterine disease, mastitis, lameness, or other health problems.
- Sexed semen is not recommended for animals receiving oestrus synchronisation and fixed-time inseminations.

### TAKE HOME MESSAGES:

- Sexed semen offers a way to predictably generate replacement heifers, although it is not yet 100% effective, with 90% of calves born being heifers.
- The greatest disadvantage of sexed semen is decreased fertility. Conception rates with sexed semen are typically 70% to 80% of those achieved with conventional semen in both heifers and lactating cows.
- The main application for the technology is on dairy heifers, with the objective of producing heifer calves. The remainder of the herd can then be bred to beef sires, providing an opportunity to increase income from the sale of cross-bred calves (or finished cattle) for beef production.
- The technology will continue to improve in the future and this may enable the more widespread use of sexed semen.
- Some farms report good results with sexed semen, while others do not. Individual farm circumstances should dictate whether it is used or not, with the best results being achieved on farms with high levels of fertility and good breeding management.

## Acknowledgements

Seidel, Jr, G. E. 2014. Update on sexed semen technology in cattle. *Animal*, 8, s1, 160-164.

## References

<sup>1</sup>Butler, S. T., Hutchinson, I. A., Cromie, A. R. & Shalloo, L. 2014. Applications and cost benefits of sexed semen in pasture-based dairy production systems. *Animal*, 8, s1, 165-172.



## GLOSSARY

**Conception rate:** the proportion of animals conceiving to a given insemination.

**Corpus luteum:** a hormone secreting structure that develops in an ovary after an ovum has been released. It is an important structure in the maintenance of pregnancy.

**DCAB:** Dietary Cation Anion Balance of a ration or individual feedstuff is calculated from the concentrations of sodium and potassium (the strong cations) relative to sulphate and chloride (the strong anions). Modifying the DCAB of the diet during the late dry period can be used to prevent milk fever.

**DNA:** Deoxyribonucleic acid is a genetic 'blueprint' containing the instructions for the development and function of life.

**Endometritis:** often referred to as 'whites', endometritis is a uterine disease occurring more than three weeks after calving, and can be present in either a clinical or subclinical form. Clinical endometritis refers to the presence of pus from the uterus, which is usually detected in the vagina. Subclinical endometritis is inflammation of the uterus with no discharge in the vagina. With both clinical and subclinical endometritis, the cow will otherwise be well.

**Gene:** basic unit of heredity, consisting of a sequence of DNA within animals' cells, and coding for a particular trait to take a particular form.

**Genetic base:** the average genetic merit of animals born in a given period, which is used as a reference point when calculating PTAs. The UK genetic base was reset in 2014, therefore you may see the term PTA2014 used.

**Genetic index:** colloquial generic term for a PTA (defined below).

**Genetic merit:** colloquial generic term for a PTA (defined below).

**Genetics:** the study of the mechanisms by which genes are passed on to the next generation, as well as the process of examining differences between individual cows in traits and characteristics that we are interested in.

**Genomics:** the study of gene structure, arrangement, regulation and expression.

**Genomic selection:** The selection of animals through PTAs derived from DNA-profiles based on many thousands of genetic markers.

**Heat detection accuracy:** the percentage of heat detections that are correct. Some cows detected as being in heat by activity monitoring technology may not actually be in heat (termed false-positives and typically determined by researchers through examination of milk progesterone levels). Studies calculate the accuracy value as:  
$$\text{number of correct oestrus detections} / \text{number of correct} + \text{false-positive oestrus detections}.$$

**Heat detection efficiency:** is a measure of how good the technology is at detecting cows in heat, the higher the percentage, the better the technology. Studies calculate it as follows:  
$$\text{number of cows in oestrus detected} / \text{number of cows actually in oestrus}$$

**Heritability:** an estimate of the degree to which a trait is passed to the next generation, and is expressed on a scale of 0 to 100%.

**Inbreeding:** arises when related individuals are bred together. The closer the relationship, the higher the level of inbreeding.

**Ketosis:** Often characterised by a pear drop like smell on the breath of affected cows, ketosis commonly occurs as the result of severe early lactation negative energy balance. The mobilization of large amounts of body fat, which is processed by the liver, in an attempt to bridge the energy shortfall, can lead to toxic levels of ketones accumulating in the blood, milk and urine. This results in a loss of appetite and a marked fall in milk yield.

**Metritis:** uterine disease that typically occurs 3 to 9 days after calving. It is characterised by a smell, watery, red-brown uterine discharge, and a clinically sick cow with decreased milk yield, dullness and fever.

**Milk fever (Hypocalcaemia):** The huge demand for calcium at the onset of milk production can cause blood calcium levels to drop significantly, leading to milk fever either before or at calving. Calcium is needed for normal nerve and muscle function and this explains the typical clinical signs of weakness and 'downer' cows that are observed.

## GLOSSARY

**Negative energy balance:** occurs when energy intake is insufficient to meet the cow's maintenance and milk production requirements, and is unavoidable in high yielding cows. It usually occurs between 1 and 8 weeks post calving, as milk yield is increasing to a peak.

**Predicted Transmitting Ability (PTA):** expresses the genetic potential of an animal as a parent. The value indicates the superiority (or inferiority) of an animal compared to an average genetic base (see also genetic base).

**Profitable Lifetime Index (£PLI):** Financial index designed to maximise farm profitability from a combination of traits.

**Recessive gene:** a gene whose expression is masked by the presence of a dominant partner. Only when two copies of the recessive gene are present will the trait be expressed.

**Reliability:** an indication of the likelihood of a PTA being a true estimate of an animal's genetic value, with values between 10 and 99%.

**Retained placenta:** also known as retained foetal membrane or retained cleansing. It occurs when the calf's side of the placenta (the foetal membranes) fails to separate from the mother's side. Retained placenta is usually defined as the failure to expel foetal membranes within 24 hours after calving.

**SARA:** Subacute ruminal acidosis, is defined as periods of rumen pH depression (diagnosed if a number of cows have a pH<5.5). It is associated with the feeding of high levels of rapidly fermented starch. For example, if large quantities of concentrates are being offered twice daily in-parlour, this causes rumen pH to fall sharply, which then takes time to recover back to normal levels. This period of low pH impairs rumen function, causing a reduction in food intake, pain and indigestion, loose faeces and low milk fat levels.

**Selection index:** an overall score of genetic merit combining information from several measured traits. Often used as a ranking index.

## AGRISEARCH BOOKLETS

- 1 SHEEP  
The Effects of Genetics of Lowland Cross-Bred Ewes and Terminal Sires on Lamb Output and Carcass Quality
- 2 DAIRY  
A Comparison of Four Grassland-Based Systems of Milk Production for Winter Calving High Genetic Merit Dairy Cows
- 3 DAIRY  
Dairy Herd Fertility - Examination of Effects of Increasing Genetic Merit and other Herd Factors on Reproductive Performance
- 4 SHEEP  
Developing Low Cost 'Natural-Care' Systems of Sheep Production
- 5 BEEF  
An Examination of Factors affecting the Cleanliness of Housed Beef Cattle
- 6 BEEF  
The Effects of Housing System on Performance, Behaviour and Welfare of Beef Cattle
- 7 DAIRY  
Developing Improved Heifer Rearing Systems
- 8 BEEF  
The Influence of Suckler Cow Genetics and Terminal Sire on Performance of the Suckler Herd
- 9 DAIRY/ BEEF  
Reducing Organic Nitrogen Outputs from Dairy Cows and Beef Cattle in Nitrate Vulnerable Zones
- 10 DAIRY  
The Effect of the Type of Dietary Supplement on the Performance of the Grazing Dairy Cow
- 11 DAIRY  
Are International Dairy Sire Genetic Evaluations Relevant to Milk Production Systems in Northern Ireland?
- 12 DAIRY/ BEEF  
Holstein Bull Beef
- 13 DAIRY  
Effective Footbathing of Dairy Cows
- 14 DAIRY  
Effects of Feeding Forage Maize and Whole Crop Silages on the Performance of Dairy Cows
- 18 DAIRY  
Reducing Phosphorous Levels in Dairy Cow Diets

## AGRISEARCH BOOKLETS CONTINUED

### 19 DAIRY

The Effect of Applying Slurry During the Grazing Season on Dairy Cow Performance  
Contribution of Meat (Beef and Lamb) from Grass-Fed Ruminants to the Total Human Dietary Intake of Long Chain N-3 Polyunsaturated Fatty Acids.

### 21 BEEF

Maximising Returns from Beef Sourced from the Dairy Herd

### 22 DAIRY

A Comparison of the Performance of Holstein-Friesian and Norwegian Red cows on Northern Ireland Dairy Farms

### 23 DAIRY

The Effect of a Number of Novel Supplementation Strategies on Milk Production and Fertility of High Yielding Dairy Cows

### 24 DAIRY

A Comparison of the Performance of Holstein-Friesian and Jersey Crossbred Cows across a Range of Northern Ireland Production Systems

### 25 DAIRY

The Effect of Applying Cattle Slurry as the Sole Source of Nutrients over a Four Year Period on the Yield and Persistency of Seven Perennial Forage Crops

### 26 DAIRY

Grassland performance and its relationship with profitability on 10 Northern Ireland dairy farms

### 27 DAIRY

The Effect of offering concentrates during the dry period on dairy cow performance

### 28 DAIRY / BEEF

Prevalence of BVD in Northern Ireland Dairy and Suckler Herds

### 29 DAIRY

Developing improved concentrate feeding and grazing strategies for dairy cows

### 30 DAIRY

The effect of early lactation concentrate build-up strategies on dairy cow performance

### Other Publications

BovIS User Guide (Carcass Benchmarking Application)  
Diagnosis and Treatment of Lameness in Sheep

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