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Reproductive management of seasonal calving dairy herds

Background: Seasonal calving herds account for around a fifth of dairy farms in the UK (AHDB 2016). Their structure allows focused farm management and seasonal labour requirements, as well as the opportunity to maximise the conversion of grazed grass into milk. However, their economic success is underpinned by a requirement for optimal reproductive management, and for this reason a thorough understanding of how to approach fertility in these herds is essential for veterinary surgeons involved in their management.

Aim of the article: This article explains the concept of seasonal calving systems, the impacts of poor fertility, the key performance indicators used to monitor performance in clinical practice, and the key areas where improvements can be made.

Concept of seasonal calving systems

The reproductive calendar of seasonal calving systems is dictated by the planned start of calving, which is typically either in spring or autumn. Rebreeding begins from the mating start date (or planned start of mating), which is around three months after the beginning of calving and is determined by the desired planned start of calving for the subsequent year (calculated as 282 days after the date of the first insemination). After the mating start date, all cows are eligible for service, unless they have been identified as barren. Cows will typically be served for up to 12 weeks, which may involve artificial insemination (AI), natural service, or periods of both. Fig 1 depicts the major events around calving and breeding.

Spring calving systems

Spring calving systems focus on keeping the cost of milk production low by maximising milk production from grazing, the cheapest feed available on farm. Cows are kept outdoors where possible, minimising feeding, housing and machinery costs. To optimise early spring grazing, some systems will set the planned start of calving based upon the 'magic day', where grass supply intersects (and subsequently overtakes) grass demand; intending on completing the first grazing rotation by this point. In any spring system, calving should occur before the onset of rapid grass growth, so that nutritional requirements are matched with pasture supply. Spring systems are reliant on producing high-quality grass lays, maximising pasture intakes and optimising pasture productivity. For this reason, they may be especially susceptible to unpredictable climatic conditions and declining pasture quality.

Autumn calving systems

Autumn calving herds will typically calve between August and November, and cattle will be kept indoors over the winter period. Management options during housing may range from low-input, self-feed silage to intensive total mixed ration-based feeding, allowing nutrition of the cow to be optimised during the period of highest yield; as yields decrease in later lactation, cows can be returned to low-cost grazing. Persistency of lactation may also be optimised, as cows may experience a second lactation peak as a result of grazing on high-quality pastures during spring (Garcia and Holmes 1999).

Consequences of poor fertility

Poor fertility in seasonal calving herds will typically manifest as an elongated calving pattern or an increased barren rate, both of which will have negative economic consequences (Box 1).

KEY LEARNING OUTCOMES

After reading this article, you should understand:

- ☐ The reproductive timetable of seasonal calving systems;
- ☐ The main impacts of poor fertility;
- ☐ The key performance indicators to measure performance on seasonal calving farms;
- ☐ How to review past reproductive performance;
- ☐ How to plan for improved reproductive performance in the future.

BOX 1: RELATIONSHIP BETWEEN REPRODUCTIVE AND ECONOMIC PERFORMANCE

Financial analysis of reproductive performance of herds in New Zealand estimated that a 1 per cent improvement in the six-week-in-calf-rate was associated with an increased payout equivalent to NZ$4 (about £2) per cow in the herd, whereas a 1 per cent increase in the empty rate was associated with a net loss of around NZ$20 (about £10) per cow (Burke and others 2008). In this study the extra milk produced by compacting a herd's calving pattern was a key driver of financial gain, since if dry off was a fixed calendar date, earlier calving cows had longer lactation lengths.

More recently, economic analysis of spring calving pasture-based systems in Ireland found that a 1 per cent improvement in six-week-in-calf-rate was associated with a cost-saving of €9.26 (about £8) and €3.51 (about £3) per annum per cow and heifer, respectively (Shalloo and others 2014). Although differences in drying off policies and costs of production make direct comparisons to UK herds difficult, they are useful indicators that improvements in fertility do have positive economic benefits.

In herds where the calving pattern is elongated, the proportion of cows calving after the first six weeks of the calving season will be increased. Late-calving cows will have a shorter interval until they are eligible for insemination and will be less likely to conceive within the first six weeks of the breeding season (Macmillan 2012) (Box 2). Replacement heifers born at the tail end of a 12-week block may be up to three months younger than those born at the start of calving, and in herds where the breeding season is longer, the age disparity will be even greater. This complicates their management at breeding; calves that are too young for insemination will have to be sold, or retained until the subsequent year if they are unable to calve within the current block.

One of the main reasons that farmers commonly desire a compact calving period is to maximise resource efficiency and minimise costs. This may be particularly obvious in herds where heat detection is outsourced, since a longer breeding season will incur a greater cost. Elongated calving periods will cause reductions in workforce efficiency, since where an overlap between calving and breeding exists, it will be more difficult for staff to dedicate attention to either area. Feeding management and forage use will also become more complicated. As the calving pattern elongates there will be a wider range of cows at different stages of their lactation. Subsequently, co-ordination of peak pasture intake with peak pasture growth becomes more difficult, as does nutrition of the herd as a single group. Finally, work-life balance of the staff will suffer as a result

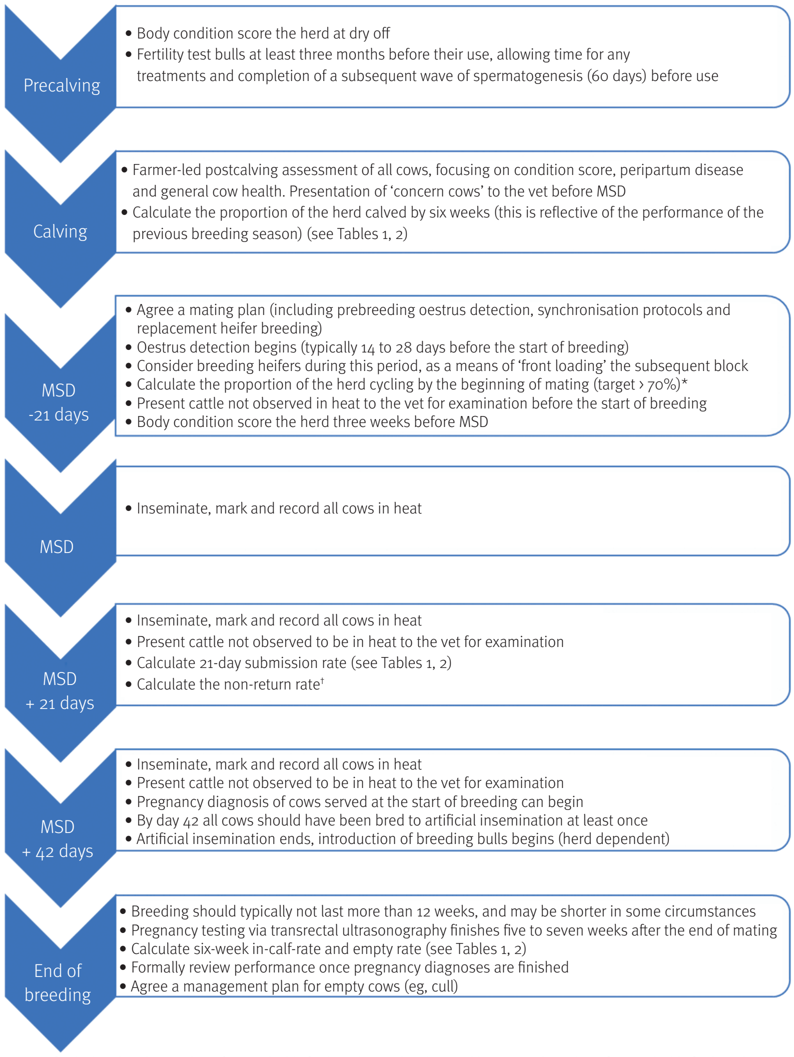


Fig 1: Example time line of actions to consider during calving and breeding.
* Calculated as the number of cows eligible for breeding with a detected heat ÷ total number of cows eligible for breeding. † Calculated as the number of served cows not seen to return to heat following insemination ÷ the total number of cows served. MSD Mating start date

of the presence of lactating cattle throughout the calendar year.

Increases in the barren rate may be the result of the reduced calving-conception interval required of late-calving cows. Non-pregnant cows will either have to be managed by extending the breeding season, 'carrying them over' until the next breeding season, or they will need to be culled. If herd size is to be kept constant then culling cattle due to poor fertility is likely to restrict the number of cows available for voluntary culling issues, such as mastitis.

Assessing reproductive performance

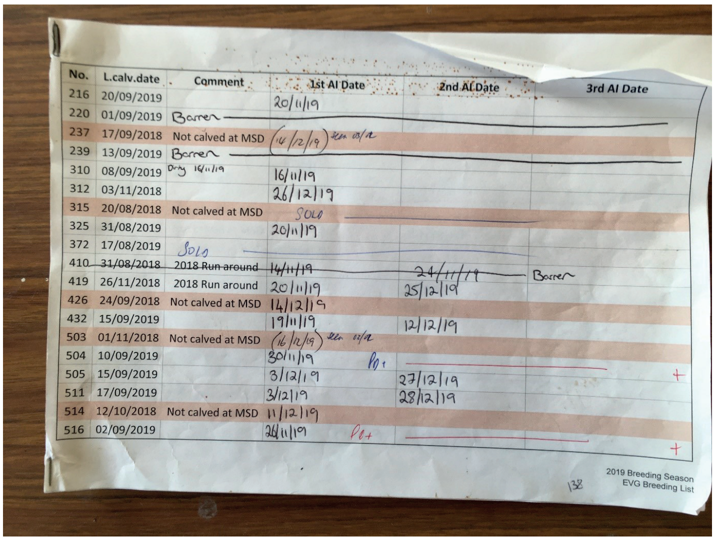
Before reproductive performance can be assessed, it is crucial that the eligible population of cattle (ie, the denominator) is defined. Ideally, this should be performed prospectively; cows intended to breed and voluntary culls should be agreed before the mating start date (Fig 2). Retrospective

BOX 2: IMPORTANCE OF THE CALVING TO BREEDING INTERVAL IN SEASONAL CALVING HERDS

In order to retain the same calendar date for the mating start date each year, a seasonal calving herd will require a calving index of 365 days. Given an average gestation length of 282 days, this means that, on average, a cow has a period of 83 days from calving for uterine involution, to return to cyclicity and for conception to occur.

Improving calving compactness requires calving replacements at the beginning of the calving season, removing cows diagnosed empty at the end of the breeding season and/or hormonal manipulation of late-calving cows in order to shorten their calving to conception interval.

Late-calving cows should be treated for postpartum disease and ultrasonographically examined before the breeding season. Cows in anovulatory anoestrus may be eligible for treatment with a progesterone-based hormonal protocol in order to restore cyclicity and guarantee submission.



No.	L.calv.date	Comment	1st AI Date	2nd AI Date	3rd AI Date
216	20/09/2019		20/11/19		
220	01/09/2019	Barren			
237	17/09/2018	Not calved at MSD	(14/12/19)		
239	13/09/2019	Barren			
310	08/09/2019		16/11/19		
312	03/11/2018		26/12/19		
315	20/08/2018	Not calved at MSD	SOLD		
325	31/08/2019		20/11/19		
372	17/08/2019	SOLD			
410	31/08/2018	2018 Run around	14/11/19	24/11/19	Barren
419	26/11/2018	2018 Run around	20/11/19	25/12/19	
426	24/09/2018	Not calved at MSD	14/12/19		
432	15/09/2019		19/11/19	12/12/19	
503	01/11/2018	Not calved at MSD	(16/12/19)		
504	10/09/2019		30/11/19		
505	15/09/2019		3/12/19	27/12/19	
511	17/09/2019		3/12/19	28/12/19	
514	12/10/2018	Not calved at MSD	11/12/19		
516	02/09/2019		26/11/19		

2019 Breeding Season
EVG Breeding List

Fig 2: Breeding decisions and voluntary culls should ideally be decided before the beginning of breeding. Retrospective analysis of breeding data inevitably results in exclusion of non-voluntary culls or cattle that fail to conceive, which may falsely improve key performance indicator calculations

calculations of performance are also possible, but the results may be falsely improved, as a result of the misclassification of involuntary culls, or inseminated barren cows, as voluntary culls. Once figures have been established, calculation of the relevant key performance indicators (Table 1) can proceed, and comparisons to industry targets or performance from previous years made (Table 2).

Proportion of the herd calved by six weeks

The proportion of the herd calved by six weeks is an excellent figure for preliminary assessment of herd performance and can easily be calculated from herd records. It accounts for errors in pregnancy diagnosis, as well as any losses (such as abortions) occurring between scanning and calving. However, its retrospective nature and inability to account for culling or replacement animals make more recent measures essential for a comprehensive analysis of reproductive performance.

Six-week in-calf rate

The six-week in-calf rate is a useful measure for benchmarking year-to-year and herd-to-herd performance, since it is unaffected by length of the breeding season. Six-week in-calf rate is driven by 21-day submission rate and conception rate, and assessment of these three measures in conjunction is a useful means of pinpointing where improvements can be made. Six-week in-calf rate is a binomial measure, so cows in-calf at the beginning of the breeding season are valued the same as those in-calf during the fifth week. For this reason, the performance of herds with similar six-week in-calf rates can be highly variable, and in such cases comparisons between smaller interval-

Table 1: Key performance indicators and their definitions*

Measure	Definition
Proportion of the herd calved by six weeks	(Number cows and heifers calved in the first six weeks from the planned start of calving ÷ total number cows and heifers due to calve) × 100
Six-week in-calf-rate	(Number of cows and heifers that get in-calf during the first six weeks of mating ÷ total number of cows and heifers selected for breeding) x 100
Empty rate	(Number of cows confirmed empty ÷ number of cows selected for breeding) x 100
21-day submission rate	(Number of cows receiving at least one insemination in the first 21 days of mating ÷ total number of cows and heifers selected for breeding) x 100
Conception rate	(Number of inseminations that resulted in a confirmed pregnancy ÷ total number of inseminations) x 100

*Adapted from data from AHDB Optimal Dairy Systems (2019)

Table 2: Industry targets for block calving herds*

Measure	Excellent (%)	Good (%)	Average (%)
Proportion of the herd calved by six weeks after the planned start of calving	›90	80	70
Six-week in-calf rate	78	72	65
21-day submission rate	90	85	75
Conception rate	65	60	50
Empty rate	‹9	‹12	16

*Adapted from data from AHDB Optimal Dairy Systems (2019) based measures, such as three-week in-calf rates, may be useful.

21-day submission rate

Results of the Australian InCalf project (an industry-funded initiative that sought to identify key factors affecting reproductive performance in Australian dairy herds) found that variations in 21-day submission rates were responsible for 57 per cent of all the variation in the six-week in-calf rate (Macmillan 2012). It is influenced by the proportion of cycling cows as well as the quality of heat detection, and interpretation of suboptimal rates should consider these issues as a priority. Submission rates can be easily improved, and a 10 per cent improvement in submission rates throughout the first six weeks of the breeding season has been associated with a 6 to 8 per cent improvement in the six-week in-calf rate (Morton 2010). Daily recording of submission rate during the first 21 days may be a useful means of measuring performance in real time (Fig 3).

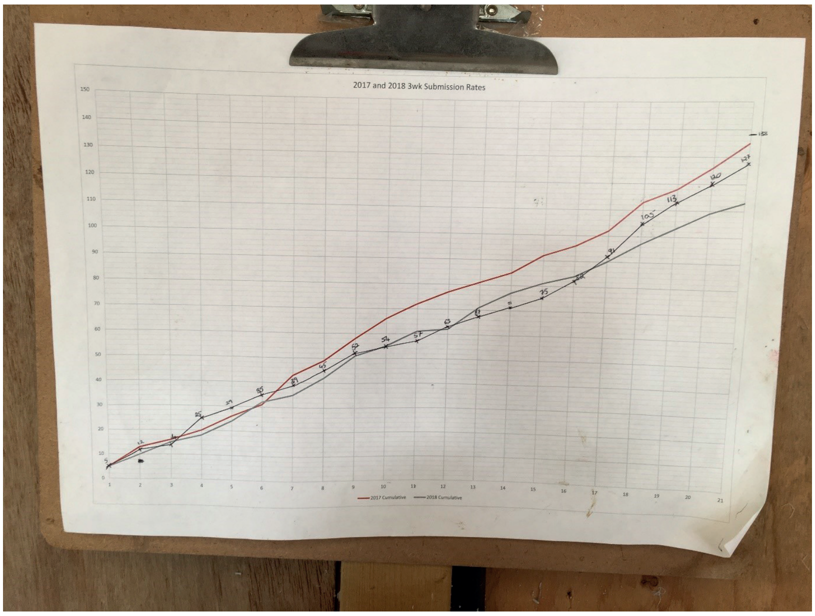


Fig 3: Daily measurement and recording of submission rates allows benchmarking between previous years, and may also provide an early warning system in cases of poor performance

Conception rate

The conception rate is a measure of the number of inseminations that result in a confirmed pregnancy. If herd conception rates fall below 50 per cent then further investigations are warranted and can be approached by considering problems related to the AI technicians, the semen or the cows. Where bulls are used, consideration and evaluation of their fertility is also necessary.

The conception rate between inseminator is an easy way to determine if problems are the result of a single inseminator, and differences between technicians of greater than 15 per cent indicates that a review is needed. Annual 'refresher' courses for all those involved with AI should be encouraged, as a useful means of preventing technician-related issues.

Semen quality problems are most commonly the result of issues with storage, handling or thawing, and assessment of semen viability following routine preparation can pinpoint such issues.

Energy balance and the time from calving until service are perhaps the two most crucial herd-level factors affecting conception rate, and calving records and body condition scores (BCS) may be a useful starting point for their review. Non-return rate may be used as a proxy for conception rate before pregnancy testing and can prove a useful early warning system for conception issues. Prudent intervention may be necessary in herds where the non-return rate drops to below 60 per cent.

As a measure, the reliability of non-return rate is dependent upon the quality of oestrus detection, and for this reason atypical increases in non-return rate may also be of concern, reflecting lapses in oestrus detection, rather than improvements in conception rate.

Empty rate

The length of the breeding season is a compromise between the empty rate at pregnancy diagnosis and the duration of the calving season in the subsequent year, and herds with suboptimal fertility are likely to initially incur a high number of empty cows if the length of the breeding season is restricted. However, in the long term, calving spread will be compacted, low fertility cows will be removed and more days in milk in subsequent lactations will be realised (Beukes and others 2010).

Key drivers of reproductive performance

The Australian InCalf project identified herd and individual cow factors that were responsible for the majority of the variation in herd reproductive performance (Table 3). While discussion of all of these factors is beyond the scope of this article, those considered most influential will be discussed further.

Herd calving pattern

In seasonal calving dairy herds, current calving pattern is the most important determinant of future

Table 3: Herd and individual level factors affecting reproductive performance*

Herd level factors	Individual cow factors
• Herd calving pattern • Body condition score • Heat detection efficiency • Artificial insemination practices • Standard of replacement heifer rearing • Bull management	• Calving and postpartum problems • Retention of subfertile cows until the subsequent breeding season • Age extremes (poorly reared heifers or cows >eighth lactation)

*Adapted from Macmillan (2012)

Fig 4: Body condition scoring of cattle should ideally be performed at strategic times throughout the year. This allows dietary adjustments to be made promptly, ensuring that the incidence of metabolic or reproductive disease is minimised

Fig 5: Tail paint is a useful heat detection aid. Cattle in heat will stand to be mounted, causing the paint to be rubbed off. On this farm, cows are marked with green tail paint after pregnancy diagnosis, to ensure the prompt identification and reexamination of 'pregnant' cattle displaying oestrus behaviour

reproductive performance (Brownlie and others 2014). This is because cows calving later will have a shorter interval from calving to the mating start date than those that calved earlier in the calving season. The result is essentially the same as a shortened voluntary waiting period; cows will have less time for resolution of uterine disorders such as retained fetal membranes or endometritis, for uterine involution and to return to cyclicity. In addition, the late-calving cows are more likely to be at peak milk production during the breeding season, and as a result are more at risk of being in negative energy balance; increasing their chances of being anovulatory, as well as reducing the risk of any pregnancy occurring at insemination (Ribeiro and others 2013). These effects are self-perpetuating; late-calving cows are unlikely to conceive early, and therefore are more likely to be barren or calve later within the subsequent lactation.

A multifaceted approach to late-calving cows is essential if the calving pattern is to be compacted. This should focus on prompt diagnosis and resolution of postparturient disease, nutritional support to promote ovulation of a viable oocyte, as well as hormonal intervention to ensure cyclicity and guarantee service at the beginning of the breeding season. Progesterone-based protocols have been shown to consistently improve pregnancy rates in cycling and non-cycling cows and may be an effective method of improving six-week in-calf rates (McDougall 2010, Herlihy and others 2011).

Body condition score

The majority of dairy cattle are expected to be in a degree of negative energy balance after parturition; as a result of rapidly increasing milk yields that cannot be matched with dry matter intakes. To meet the deficit, energy is mobilised from fat reserves. Large increases in either the magnitude or duration of negative energy balance will have a substantial impact on conception, submission and pregnancy rates (Buckley and others 2003, Roche and others 2007). Irish research has demonstrated that cows with a BCS below 2.75 at breeding had a six-week in-calf rate 8 per cent lower than those with a BCS of between 2.75 and 3.00 (Buckley and others 2003). Similar reductions were demonstrated in cows that lost over half a condition score between calving and first service. These effects are predominantly mediated through the duration of postpartum anoestrus interval; that is, the extended length of time it takes for thin cows, or cows with excessive condition loss, to return to cyclicity. Given the restricted time frame in which cows are required to become pregnant in seasonal calving herds, minimising condition loss and timely identification and treatment of anovulatory anoestrus cows before the beginning of the breeding season is essential. Non-invasive measurement of energy balance can be achieved by body condition scoring cattle at key periods of the year, typically at around dry off, calving and mating (Fig 4). Precalving BCS should be between 3.00 and 3.25 and cows should maintain BCS of 2.75 or greater during the breeding season. In circumstances where further investigation of energy balance is required, strategic measurement of serum non-esterified fatty acids or serum β-hydroxybutyrate levels at key periods may be useful (Smith and others 2014).

Heat detection efficiency

Heat detection should begin between two and

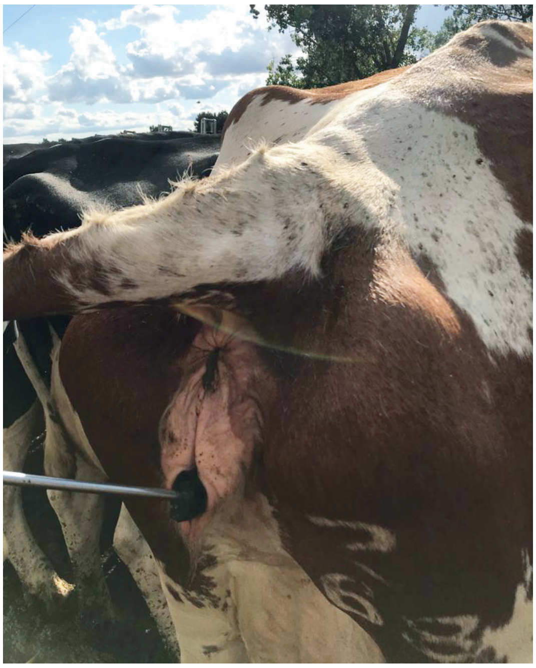


Fig 6: Prebreeding examination of cattle allows the prompt identification and treatment of cattle with reproductive disease before mating begins. A Metricheck (Simcro) device may be used to assist in the diagnosis of endometritis

Fig 7: Differences in artificial insemination (AI) technique can have profound effects on conception rates. On farms where conception rates are suboptimal, investigating the AI practices of those involved can identify areas where improvements can be made

four weeks before the start of mating and the use of aids, such as tail paint (Fig 5), should be accompanied by manual observation. Cattle should be easily identifiable, and recording those cows seen in heat and marking them differently will help to identify cows who have not been observed in oestrus, so that they can then be presented to the veterinarian before the beginning of breeding (Fig 6). Measurement of the percentage of herd cycling by the beginning of breeding is a useful predictor of heat detection efficiency (Fig 1). In herds where less than 70 per cent of cattle have been detected in heat by the beginning of breeding, timely intervention may be required to differentiate true anoestrus from poor heat detection, and this can be achieved through the use of rectal ultrasonography. Anovulatory cows will most commonly present with small ovaries and the absence of a corpus luteum. In comparison, the presence of a corpus luteum indicates that ovulation has occurred, and an oestrus event missed (Wiltbank and others 2002).

'Management problems', such as not dedicating time to oestrus detection alone, accounts for 90 per cent of cases of failure to detect heat (Diskin and Sreenan 2000), and for this reason all those involved in heat detection should be trained and aware of all the signs a cow might display. The accuracy of oestrus detection can easily be assessed by investigation of interservice intervals. Inseminations performed at intervals of 18 to 24 or 36 to 48 days are considered normal or indicative of a missed heat, respectively, while intervals outside of these ranges are abnormal. More recent research has suggested that normal interservice intervals may be more variable, and a range of 18 to 28 days may be more accurate (Remnant and others 2018).

Artificial insemination practices

The Australian InCalf project found that at least 40 per cent of 'do-it-yourself' AI technicians could achieve a 5 per cent improvement in their conception rates by improving their AI practices, highlighting that gains can be made on the majority of farms. AI management should focus on the timing of insemination, semen storage, handling and defrosting, insemination technique (Fig 7), and cow handling technique. Recording service outcome alongside who identified oestrus and who inseminated the cow allows individual staff performance to be measured.

Bull management

Successful bull management encompasses running an appropriate number of bulls that maintain health and fertility before and throughout breeding. Purchase of new bulls should take place a minimum of three months before they are required. Upon arrival, new bulls should be placed in quarantine for a minimum period of four weeks and tested for disease status, if not already performed. Around one in four bulls have inadequate semen quality, physical soundness or serving capacity and a breeding soundness exam should be considered mandatory before use (Fig 8), especially given that the economic benefits associated with improved reproductive performance outweigh the cost of any examination (Dwyer 2013).

Fig 8: Bull breeding soundness examination should be performed on all bulls before their use

Practical determination of bull power required is challenging; in herds where a bull is used following a period of AI, the exact number of bulls required will vary based on the number of open (non-pregnant) cows at the beginning of bull use. This presents a temporal difficulty, since decisions on bull numbers will be made before breeding. In general, ratios for mature breeding bulls should be around 1:30 non-pregnant cows, although calculators exist for more specific determination of required bull power (AHDB 2019). In herds where bull breeding follows six weeks of AI, we would suggest a ratio of 1:60; allowing for sufficient power to manage average six-week-in-calf rates with some additional buffer. In situations where synchronisation, young or maiden bulls are used, ratios will need to be lower. Bulls should be a similar size to the cows they are breeding, and calving ease (based upon breed and estimated breeding values) should be a key consideration, especially if they are to be used on the heifers. Practically, the ease of which differentiation can be made between calves born as a result of AI or natural mating is an important consideration. Bulls should be kept in the same groups before and during mating and frequently observed to ensure they are performing. To ensure bull preservation, they should be rotated frequently throughout the mating period and rested before reintroduction into the herd. Their performance can be assessed once pregnancy diagnoses are complete, through evaluation of the pregnancy-to-the-bull mating-period and the empty rate.

Calving and postpartum problems

Calving and postpartum health problems are associated with extended periods of anoestrus, reduced conception rates, and greater risk of pregnancy loss and may be the result of reproductive tract pathology, impaired cyclicity or oestrus expression (Ribeiro and others 2013). Following calving, the likelihood of uterine infection and subsequent metritis or endometritis is increased as a result of dystocia, caesarean section, twinning, retained fetal membranes, milk fever and ketosis, and cows diagnosed with disease should be closely monitored. A strategy for assessment of individual cows should be developed with the client. Whole herd Metricheck (Simcro) examinations – a procedure to identify cows that have endometritis – may be performed by the farmer or vet (Fig 6). Alternatively, high-risk cows and those not displaying signs of oestrus may be presented for veterinary examination before breeding, typically up to 14 days before the mating start date. In the long term, prevention of periparturient and postparturient disease through appropriate breeding strategies that minimise dystocia and optimal nutritional management should be a focus.

Developing a strategy for your farms

An effective reproductive strategy must be consistent, set achievable targets and motivate all those involved. Performance should be reviewed following the end of pregnancy diagnoses, and areas of concern flagged. A subsequent planning meeting before the beginning of calving should provide practical strategies to address any highlighted issues, while also reconsidering the key drivers of reproductive performance and how they may be fine-tuned. Before the beginning of breeding, all cows in the herd should be reviewed. This allows breeding and culling decisions to be made and expectations to be set (Fig 2). Good performance one year is not a guarantee of good performance in subsequent years, and planning before calving begins can really pay dividends.

Summary

Assessment of reproductive performance in seasonal calving herds requires a different approach to that of year round herds. However, assessment of current reproductive performance can quickly be attained from readily available records, and areas of poorer performance recognised. Thorough attention to detail is essential for optimal performance, and consistent veterinary advice tailored towards each farming system will allow real improvements in animal health and welfare, as well as profitability to be made.

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SELF-ASSESSMENT: REPRODUCTIVE MANAGEMENT OF SEASONAL CALVING DAIRY HERDS

***In Practice* partners with BMJ OnExamination to host self-assessment quizzes for each clinical article. These can be completed online at inpractice.bmj.com**

1. **In seasonal calving dairy herds, anovulatory anoestrus is most commonly associated with which two factors?**
   a) Postpartum negative energy balance and duration since calving
   b) Periparturient and postparturient disease
   c) Poor heat detection efficiency and submission rates
   d) High milk yields and poor artificial insemination technique

2. **The two most important performance indicators influencing the six-week in-calf rate are:**
   a) Proportion of the herd cycling by the beginning of breeding and 21-day submission rate
   b) Non-return rate and empty rate
   c) 21-day submission rate and conception rate
   d) Proportion of the herd cycling by the beginning of breeding and the non-return rate

3. **In seasonal calving dairy herds the most important determinant of future reproductive performance is:**
   a) Body condition score
   b) Heat detection efficiency
   c) Culling and replacement policy
   d) Current six-week in-calf rate

4. **Heat detection should ideally commence:**
   a) At the beginning of breeding
   b) Seven days before the beginning of breeding
   c) 42 days before the beginning of breeding
   d) 14 to 28 days before the beginning of breeding

Answers: (1) a, (2) c, (3) d, (4) d