DairyCo

Review of calving pattern management in dairy herds

Report prepared for DairyCo (MDC) by IGERS

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A Review of the Calving Pattern Management in Dairy Herds

OBJECTIVE OF THE PROJECT

The objective of the project is to evaluate different calving seasons and their implications in relation to herd performance, management issues and financial viability. The literature review will evaluate results from a range of studies conducted both in Europe and other countries. The production of a flow chart and sensitivity tables will allow the individual farmer to assess the impact of changing from their current calving pattern to an alternative option. To ensure information is sourced from a wide range the literature review includes published scientific papers (e.g. Journal of Agricultural Science, Journal of Dairy Science, Livestock Production Science, Journal of Agricultural Science, Grass and Forage Science, New Zealand Journal of Agricultural Research), conference proceedings, technical reports, dissertations, WEB databases, specialist databases and also relevant facts and articles from popular journals including British Dairying, Dairy Farming, Farmers Weekly and International Dairy Topics.

PART 1: Review of Literature

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2. SUMMARY OF THE REVIEW OF LITERATURE

- The calving pattern of a dairy herd is either:

(a) the result of a decision to set pre-defined targets to achieve a specific calving period OR

(b) non-specific due to problems in relation to reproductive efficiency (heat detection, conception rates), inadequate diet (low energy density of the diets in early lactation) or disease.

- Changing the calving pattern can potentially have a greater impact on both high-yielding dairy cow and herds on high-forage diets (e.g. pasture-based systems) compared with lower yielders or herds fed diets with a higher proportion of concentrate .However, the effect of changing the calving pattern is also influenced by the quality of the diet, primarily energy density per kg DM, and level of intake achieved.
- Changing the calving pattern of a herd can be achieved in three ways:
    1. By changing the calving date of homebred heifers
    2. By manipulating the calving dates of cows already in the herd
    3. By purchasing additional stocks
- Any change in the calving pattern is likely to have financial implications: (a) milk income will be reduced if there is an increase in the number of days from calving to conception, (b) replacement costs will be increased if first calving date for heifers is delayed and, (c) extra investment is required if additional stock are purchased (without the purchase of stock the existing herd size will reduce during the change-over period due to natural culling).
- The calving pattern selected for a herd will be influenced by:
    1. The milk pricing system of the milk buyer (e.g. seasonal versus dual payments)
    2. Whether the farm is suited to the change in relation to farm location, management implications and ability to maximise performance and efficiency of production from the system. Spring-calving herds producing milk primarily from grass will need to achieve low costs of production to be viable, conversely a high-input system based on TMR diets will need to feed diets of consistent high quality to ensure the higher costs of production are offset by efficient feed conversion into milk and high lactation yields per cow.
- Systems based primarily on grazed herbage (e.g. Spring-calving herds) that efficiently manage and utilise their pastures are characterized by high milk output per unit of land, while housed systems are characterized by high milk output per cow.
- For many high-yielding herds the choice is whether to aim for efficient reproductive performance, high pregnancy rates and high milk yields per cow or aim for a tight calving pattern within a specified season that may result in a higher proportion of barren cows being sold as they have not conceived within the pre-defined period. However, on farms where (a) the milk price is linked to seasonality payments by the milk buyer or (b) the supply of quality feed cannot be maintained throughout the year the latter strategy will be essential.

- Regardless of the calving pattern the type and availability of diet influences both milk persistency during lactation and total lactation yields.
- The type and potential performance of the cows within a herd is an important factor. The increase in the genetic potential within many herds, primarily attributable to the Holstein breed, has led to significant improvements in milk yield per cow but not an improvement in the conversion of feed energy into milk. There is a correlation between dairy cow genotypes (breeds, cross-bred, within-breed genetic differences) and the large differences that can occur between the quality (primarily energy) and availability of diets in different seasons of the year. Cows of lower genetic merit have the potential to milk, breed regularly and maintain body condition within different calving patterns and under contrasting (low, high input) management systems. However, for many herds with higher genetic merit cows managing these in low input systems is more challenging in terms of meeting the cow's energy requirements in early lactation, maintaining milk persistency during lactation and achieving high pregnancy rates.
- Increasing milk yield/cow can be correlated to longer calving intervals but is also influenced by the type of diet. It is possible for a high-yielding herd fed a balanced TRM diet and averaging >8,000 litres to have a tighter calving pattern than a spring-calving herd fed <0.5 tonnes of concentrates, averaging 5-6,000 litres but having inadequate feed energy intake due to limited herbage intake and/or low herbage quality . Therefore, in a system where feed energy input may be limited, as occurs with some grazing and grass-silage based rations, high-yielding cows are vulnerable to a negative energy shortage that can lead to metabolic disorders, reduced fertility, reduced milk persistency during lactation and a failure in some systems to calve within the target time period. The financial consequences of delayed conception are greater for high-yielding cows (e.g. cows yielding 10,000 litres) compared with lower yielding cows (6,000 litres).
- While the effect of temperature on herd performance is normally a problem associated with countries that have either lower winter or higher summer temperatures, the reproductive performance of autumn-calving cows can be affected by cold winter temperatures. Conversely hot summer temperatures can reduce the fertility in both spring and summer-calving herds, with UK summer-calving cows adversely affected.

<u>Spring-calving pattern</u>

- A spring-calving pattern is usually classified as a low production system with milk primarily produced from low cost diets based on grazed herbage. Compared with an autumn-calving herd the cost of milk production will normally be lower from a spring-calving herd producing milk primarily from grazed herbage, however, both the lactation length and total milk yield will also be lower.

- The most efficient herbage utilisation is from cows reaching peak yield at turnout rather than calving occurring at the same time as turnout.
- Spring-calving cows often have shorter lactations compared with those calving in the autumn, attributable to declining herbage availability and quality as the grazing season progresses.
- Supplementing the grazed herbage of spring-calving cows with concentrate feeds has shown variable results in terms of both milk production and financial benefits with other factors, including stocking density, influencing the results. The milk yield response to concentrates is influenced by both the availability and quality of the grazed herbage. Total intakes from grazed herbage are unlikely to exceed 19 kg of DM per day and unless the stocking density is very low and herbage availability high, cows yielding >25 litres will respond to supplementation both in relation to increased milk yield and improved fertility.
- Short term supplementation of the grazed herbage with concentrate feeding and/or buffer feeds may have longer-term benefits, including better pasture management, positive effects on body condition and fertility, better milk persistency, improved milk quality and extended lactation length. However, the costs of production are increased.
- Grass/white clover pastures can increase milk production but excess protein in the diet from mid-summer onwards and the potential risk of bloat need to be considered.
- Reducing the stocking density during grazing increases herbage intake per cow and milk yield per hectare but reduces both the efficiency of herbage utilization and milk yield per cow. A leader/follower grazing system can increase milk yields by allowing the high yielding cows to graze before those with lower yields.

Autumn-calving pattern

- The management of autumn-calving herds ranges from low input, easy feed systems to intensive systems based on TMR and both higher concentrate inputs and milk yields per cow. Compared with spring-calving herds, primarily based on low concentrate inputs, the range of systems is greater in autumn-calved herds and in many herds the higher milk yields, both per cow and per hectare, offset the higher costs of production.
- On some farms autumn-calving will lead to peak yields being produced when milk prices are higher if the milk buyer is paying seasonality payments.
- The type of feeding system (easy feed, TMR etc) used to manage the autumn-calving herd will have a marked influence on machinery & labour requirements, silage intakes and herd performance.
- Autumn-calving herds benefit from a ‘second’ milk peak when cows are turned out to graze in the spring.

Summer calving

- To be viable a summer-calving system is dependent on higher milk prices via seasonality payments to offset the higher feed costs. Sustaining milk persistency during lactation may require the feeding of both high-quality forages as a buffer feed and extra concentrates as the peak milk production does not coincide with optimal herbage quality and availability.
- The incidence of disease may be lower in summer-calving herds as cows can calve outdoors where the risk of infection spreading between cows is minimized (e.g. environmental mastitis).

Year-round calving pattern

- A year-round calving pattern in dairy herds is either a result of (a) a management decision to aim for an even supply of milk throughout the year or (b) the result of problems in the management of the herd including poor diets during early lactation, delayed conception and extended calving intervals that have led to a failure to maintain a calving pattern within a pre-defined period.
- The option of dividing the herd into sub-groups that are based on milk yield is an important consideration when cows calve all the year round.
- Grazing management for these herds may favour a leader/follower system to optimise milk production by allowing the high-yielding cows to graze the best quality herbage.

Block calving in a dairy herd

- On some farms block calving is an essential part of the management strategy to match peak milk production with the cheapest feed (i.e. grazed herbage) and/or to meet the requirements of the milk buyer.
- With the exception of lower genetic merit cows (e.g. dual purpose breeds), a block-calving pattern requires high-quality diets in early lactation to ensure high conception rates and c.90% of cows calve within a pre-defined period of c.8 weeks.
- Benefits include the occurrence of specific events (calving, passports, heat detection, insemination, drying off etc) which are completed within a short time period. Disadvantages include the high peak of labour required during the calving and early lactation period.
- Maintaining a tight calving pattern will inevitably lead to difficult decisions, including the culling of some high-yielding cows that fail to conceive by the pre-defined conception date.
- A tight calving pattern in a herd that is managed with low concentrate inputs also increases the risk of low protein values in the milk during the early lactation period when a large negative energy balance between the cow's nutritive requirements and the quality of the diet occur.

- Currently the average herd calving index in the UK is greater than 410 days and block calving is harder to achieve in (a) herds with high genetic merit cows and (b) in systems based on very high forage diets and minimal concentrate inputs.

3. INTRODUCTION

Reduced financial margins and the change in CAP are leading to a reassessment of the future management and viability of UK dairy enterprises. Some dairy farmers will change their system of management, including expanding the dairy unit to a more economic size, targeting niche markets or deciding to be involved in both milk production and processing. The number of dairy farmers will decline as some diversify into either alternative farming or non-farming enterprises or careers. Those that remain in dairy production will need to evaluate how they manage their enterprise and consider whether the current system can be improved. One of the factors many farmers will review will be the calving pattern in relation to the profitability and management implications for the whole farm.

The increasing problems of infertility, disease and higher culling rates (Dechow *et al.,* 2004) also affect both herd performance and profitability and any potential changes that are likely to occur due to a change in the calving season need to be considered, including in many herds the ability to maintain calving dates within the target period. The season of calving within the herd not only influences the supply of milk during the year but can also have a major effect on the herd's pattern of feed requirements (Garcia & Holmes, 1999). Both the type of feeds available (both homegrown and purchased) available during the early lactation period and the costs per unit of milk are important factors to consider when deciding on the most appropriate calving season for the herd. The availability of sufficient quantities of quality feed during the critical early lactation period is essential as a negative energy balance and a lower than optimum body condition score is correlated to an increase in both metabolic disorders and poor cow health (Dechow, 2004).

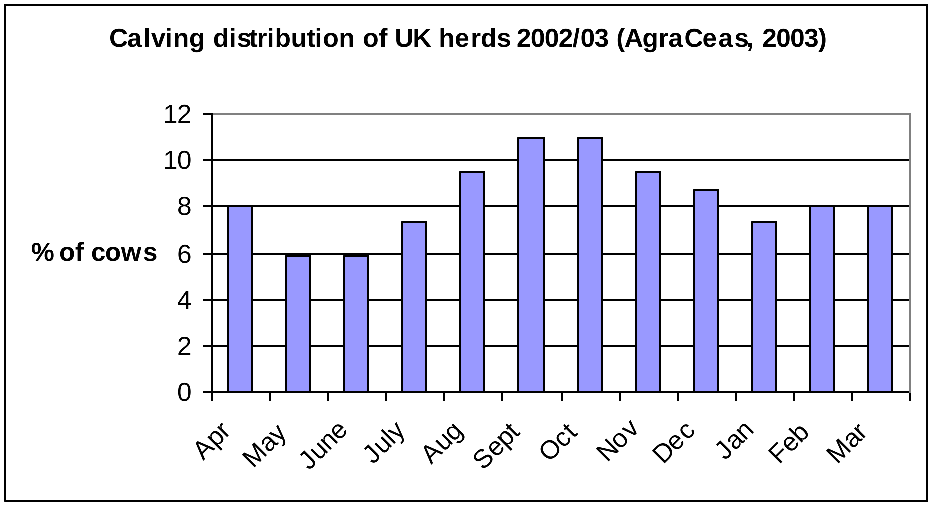
Calving patterns and the production of milk from different diets varies between countries, ranging from herbage systems in Ireland and New Zealand, where the calving season is planned to ensure maximum production from quality herbage, to diets in some areas of the USA and Israel that are based from necessity on conserved forage and concentrate feeds to sustain markedly higher yields per cow (Taylor, 1982; Dillon *et al*., 1995; Scanlon, 2003). In New Zealand the seasonal block calving pattern is primarily influenced by three factors: the need to produce milk from grazed herbage, low fixed costs and a suitable climate with a good growing season and without the requirement for either winter housing or the storage of large quantities of conserved forages (Fox, 2004). Fox (2004) found that farmers responded to milk price changes by changing the variable costs including stocking density, quantity of purchased feeds and fertiliser inputs. When prices fall farmers change to less intensive systems with a lower stocking density and reduced inputs. He also compared the culling rates of herds in both low input New Zealand herds and more intensive/high output herds in California and reported culling rates of less than 20%, in New Zealand, allowing surplus heifers to either be sold or used to expand the herd, compared with culling rates of 35% in California where dairy farmers struggle to breed sufficient replacements.

In the USA both the calving season and attainment of peak milk yields is primarily influenced by the need to match maximum milk production with peak market requirements (Scanlon, 2003) After studying dairy systems in Australia, New Zealand and the USA, Fox (2004) concluded that the successful dairy farm concentrated on the quantity, quality and cost of the feed provided for the dairy herd, irrespective of whether the farm was a well-managed grazing system in New Zealand or an intensive feedlot system in the USA. He reported that accurate measurement and feed quality assessment to achieve maximum dry matter intakes were key drivers in the profitability of a dairy system. These conserved forages are not only high quality but also provide a drier, and in many cases a less acidic diet, than those available for feeding in the UK during the winter period. For many countries, including the UK, an intermediate system between the two feeding extremes may be the most practical option when climatic conditions are taken into account.

In Ireland optimal performance is achieved from systems based on producing high yields from grazed pastures and without high inputs of concentrate supplements (Dillon & Stakelum, 2000). Seasonal milk production is a feature of the Irish dairy industry with 85% of manufacturing milk mainly produced from herbage-based systems between March and October (Ryan, 1999).

A previous survey of herds in the UK showed the overwhelming majority of cows calved in the August-December period (ADAS, 1987). However, a recent report (Holt-Martyn, 2003A & 2003B) has shown that the trend was to increase the quantity of milk produced in the Spring. By 1995 daily spring production per day was 38 million litres of milk, increasing to 41 million litres by 2003. However, increases in the National spring flush of milk was attributed to herds moving from a summer to autumn/early winter calving pattern, not because more herds had changed to calving in the spring. At the same time winter milk production has remained relatively consistent at 36 million litres/day during the 1997-2003 period. Over supply during the spring has led to lower farm gate milk prices (Holt-Martyn, 2003A). Holt-Martyn (2003A & 2003B) suggested that milk production in the UK was now leveling out and the dairy industry was moving gradually towards a year-round calving pattern. Figure 1, published by AgraCEAS (2003), used information from Promar Milkminder data to show the current differences between the proportion of cows + heifers calving in each month, with peak calving occurring in September and October.

Figure 1: The calving distribution of UK dairy herds.



It should also be noted that the genetic potential of the majority of UK herds and their suitability for all types of dairy systems and calving patterns has changed, with many high genetic merit cows (e.g. Holsteins) capable, providing the right diets are fed, of consuming 3.5-4.0% of live weight compared with intakes of 3.0-3.25% of live weight that were previously recorded (Leaver, 2000).

Measurement units & abbreviations used in the text

DM Dry matter
DOMD Digestible organic matter in the dry matter
Herbage: term used to describe the fresh forage consumed by the cow from either grazed grass monocultures (i.e. ryegrass grown in fertilised swards) or grazed mixed grass/clover swards grown either no N-fertiliser inputs or a small quantity of N-fertilser to stimulate the spring growth of grass in the sward.
TMR Total Mixed Ration or Complete Diet

One kg of milk = 0.978 Litres
One litre of milk = 1.03 kg

4. SOME MANAGEMENT IMPLICATIONS TO CONSIDER WHEN CHANGING THE CALVING PATTERN OF A HERD

4.1. Labour requirements

Changing the calving season may have a significant impact on labour requirements for the staff associated with the dairy enterprise. On a mixed farm the labour requirements for other enterprises may be affected. For example cows block calving in the August to early September period require extra attention when additional labour is also required for harvesting, ploughing etc. Changing the calving pattern may also affect daily milking times and the number of cows milked per hour if for example a herd is changed from a year-round pattern to block calving within a short period of time. A block-calving herd requires seasonal peaks of labour, particularly during the calving period, but would also have the advantage of reduced labour requirements at other times of the year. In a comparison of different dairy systems White *et al*. (2002) reported that labour costs were lower for the spring-calving herd compared to those in an autumn-calving system.

4.2. Capital availability and production costs

Extra capital may be required if the calving pattern is changed from a low-cost simple self-feed silage system or spring-calving system to one based on autumn calving and the change to high-quality diets provided from TMR diets as the latter system requires extra machinery (e.g. purchase of a new mixer wagon, extra tractor/loader input). Conversely changing from an autumn-calving to a spring-calving pattern, where the bulk of the milk is produced from grazed rather than conserved forage, may allow the capital investment in machinery to be reduced. Autumn-calving herds have higher costs for labour, forage production and manure storage & handling compared with a pasture-based system of milk production (White *et al*., 2002).

4.3. Requirement for extra buildings

The number of calving and isolation boxes required may increase when for example the calving pattern is changed from year-round to block calving during the winter housing period. Amies suggested that for a 100 cow herd calving year-round 5-6 calving boxes were required if good hygiene standards were to be maintained. Changing to block calving within a 12 week period would require 10-12 boxes + isolation boxes unless weather conditions allowed outdoor calving to take place. One solution on some farms with limited individual boxes could be to let cows calve in a loose yard if a suitable building is available – compared with individual boxes that are thoroughly cleaned out after each cow this option is less attractive in minimising disease risks. Similar to the requirements for calving boxes a change in the calving pattern may increase the number of individual calf rearing units required and Amies suggested up to 40 extra pens would be required for a 100 cow herd with a tight calving pattern. The purchase of calf hutches may alleviate the problem on some farms.

Autumn calving cows in early lactation will consume markedly higher quantities of forage than spring calvers in late lactation/dry period and particularly in high-forage systems the total silage requirements will vary between the different calving patterns.

4.4. Bulk tank capacity and bedding materials

Moving from year-round calving to block calving in one season may require capital investment in a new or secondhand bulk tank with a larger capacity to cope with the increase in the daily output of milk.

Changing the calving season may affect the quantity of bedding that is required for the winter housing period. Estimates of the bedding requirements include 0.5-1.0 t of straw for cubicle housing, 1.5-3.0 t of straw for loose housing and 1-3 t of sand (Green & Bradley, 2001; www.fawc.org.uk/reports/dairycow), with differences influenced by the climate and period of housing and also the type of diet fed during the winter. The recent introduction of bark pads on some farms in drier areas also offers the opportunity for changing the type of bedding used. Cows calving post-turnout will have a much lower bedding requirement compared with for example an autumn-calving herd.

4.5. Buffer feeding during the grazing season

The buffer feeding of forages for grazing dairy cows after milking, was introduced in the 1980's (Leaver, 2000) as a means of buffering against shortages in herbage availability and also to ensure more stable intakes during changing weather conditions that can occur post turnout. Grazing fresh herbage offers the best opportunity of providing the optimum forage quality for the high yielding cow (particularly a spring-calving herd) but cows may be vulnerable to the effects of a more erratic pattern of daily DM intakes. In some years adverse weather after turn-out can cause problems associated with low intakes and an increased incidence of metabolic disorders. In 2004 many early lactation cows were found to have serious energy problems soon after turnout with some showing signs of clinical ketosis (Whittaker, 2004B). MDC (2000) concluded that buffer feed should be fed directly after milking and before cows return to the grazing swards and suggested that normally a 45-minute period after milking was enough to allow cows to eat sufficient buffer feed, regardless of whether they were/were not being fed concentrates in the parlour. However, in times of extreme herbage shortage a longer feeding period would be required.

Feeding an alternative drier forage after milking and prior to the cows returning to pasture can be beneficial in minimising the risk of problems, but only if the quality of the forage (e.g. silage) is high (Whittaker, 2004B) and cows consume adequate quantities (MDC, 2000). In many years, particularly in drier areas of the UK, buffer feeding is required later on in the grazing season when both the quality of herbage declines and/or availability is restricted (ADAS, 1985) and ADAS (1987) suggested offering a buffer feed of either good quality silage or a straw/compound mix for one hour after each milking and suggested that 2.0 tonnes of buffer feed might be required; however, the quantity will vary annually due to between season growth patterns of the grass or grass/clover leys. It should be noted that to achieve a balanced energy to protein ration in the total diet the protein content of buffer feeds will need to be different for grass-only diets compared with the higher protein of grass/white clover diets from June onwards.

The suitability of a specific calving pattern for a dairy herd may be influenced by the need to provide a buffer feed (e.g. silage, forage + concentrate mix) to compensate for either a shortage of herbage for grazing or the decline in quality of the herbage. Farms in areas suitable for growing maize would have a high-quality and palatable forage to feed, while other farms may rely on whole-crop cereals, grass silage or grass/legume silage. Questions to be answered include: (a) will the forage keep its quality until required when the temperatures are higher (e.g. whole-crop cereals in bales/clamps may be vulnerable to either heating as air temperatures increase or may have been damaged by rats during the winter period. Maize silage can also be more difficult to conserve for feeding during the grazing season than grass or grass/clover silage; (b) is there a suitable storage area for the buffer feed that will not interfere with silage making either in terms of reducing the required storage capacity or being inaccessible once the new season's silage has been made.

4.6. The implications of both producing and processing the milk on the farm

Changing from being solely a milk producer to a producer/processor may require both a re-think of the current calving pattern and considering the option, where milk quality is low or varaible, of acquiring some cows of a different breed to sustain milk quality if the herd is to be the sole provider of the milk for processing. It is well proven that a failure to produce milk with a satisfactory quality (e.g. high cell counts, low protein content) can markedly increase processing costs associated with either a lower yield of the processed products (Politis & Ng-Kwai-Hang, 1988) or the need to evaporate 12-13% of the water from the milk to increase the proportion of solids (Rowlands, 1997 – personal communication), both factors leading to a reduction in the profitability of the enterprise.

4.7. The implications of either land disposal or acquisition of new land

The financial gains from disposing of part of the land used for the dairy enterprise (e.g. use of the land for residential houses or industrial buildings) may lead to a requirement to intensify production on the remaining land by increasing the stocking rate and feeding more concentrates to sustain milk production levels. Adding extra land to the existing dairy unit may allow more flexibility in the management of the dairy enterprise and lead to a strategy of managing a more extensive system that would include extended grazing or feeding diets with higher forage content. Changes in the land area of the dairy unit either from purchasing or renting extra land or the disposal of some of the existing land area, may have implications for the current calving pattern of the herd.

4.8. Culling policy

Involuntary culling will always occur in a dairy herd, whether through ill health or death. However, in some countries there is a management decision to carry out an annual cull of a high number of first-lactation heifers who fail to reach the lactation targets that have been set. For example in Denmark where the target annual herd average is c.8,000 kg, an average culling rate of 40% has been reported (Kristensen & Struck Pedersen, 2001) and in the USA culling rates of 30.0-40.8% have also been reported (Jalvingh *et al.,* 1993A. If the decision is to change the calving pattern via only the heifers rather than just the cows or cows + heifers, these herds with their high culling rates have the opportunity to change the calving pattern of a herd much quicker than those with a 20-25% culling rate.

4.9. Managing the herd in a single group or sub-groups

Whether a herd is kept in a single group or as sub-groups has important implications for the management of a dairy farm, including labour inputs, size of grazing paddocks, feasibility and type of diets fed during the winter period. While on a small farm grouping may not be possible, in a larger herd it may be essential to ensure the work is physically manageable within the existing facilities. Grouping is likely to have the greatest impact in herds calving throughout the year but will also be effective for other herds with tighter calving patterns.

As reported by Chamberlain & Wilkinson (1998) there are conflicting views on the merits of dividing a herd into sub-groups based on either milk yield per cow or the separation of heifers from cows. Some views suggest that sub-groups, whose population will change as individual cow yields increase/decrease or cows either calve or go dry, lead to unstable groups, increased bullying, more complex rationing and increased time required for feeding and milking the herd. Others argue that sub-groups improve feeding precision, reduce wastage, improve oestrus detection and ensure the appropriate body condition score is maintained throughout the lactation. For example in California where cows are fed TMR diets throughout the year (Allen, 2003) cows are generally grouped according to fertility status and body condition, rather than on the basis of milk yield. Krohn & Konggaard (1979) also concluded that separating a herd into sub-groups was beneficial with first lactation heifers that are kept separate from the rest of the herd spending 10-15% more time eating and recording 20% higher intakes.

4.10. Changing lifestyles

Dairy farming has changed radically over the last decade, including the balance between the time spent managing the farm and time with both family and other social activities. The type of calving pattern influences the balance in time allocation and, for example, dairy farmer Robert Craig (Dairy Farmer, 2003) changed from a more intensive year-round calving pattern to a less intensive spring-calving pattern to reduce the long hours required on the farm and increase the time he spent with his young family. Block-calving a herd offers the opportunity to have a period when no milking takes place, however, a tight calving pattern annually is essential to achieve this quieter period. Many dairy farmers either through desire to widen their interests or financial necessity may also wish to change their current management system For example on some smaller farms there may be a desire to undertake a completely new enterprise or part-time career either on or off the farm, with the objective of either pursuing personal ambitions or boosting total income.

5. OTHER FACTORS AFFECTING ALL CALVING PATTERN OPTIONS

5.1. The relationship between milk yield per cow, the calving season and incidence of disease

The major disease problems in dairy herds that lead to the culling of cows from the herd are lameness, mastitis and infertility (Kossaibati & Esslmont, 1995) with infertility increasing annually as the average milk yield/cow in the UK increases.. However, in a recent survey by Kingshay (2004) increasing milk yield/cow did not appear to lead to a consistent increased culling rate for all three problems. For example in high-yielding herds (>9,000 litres/cow) mastitis was the main culling reason but the proportion of cows culled due to infertility lower than in herds with milk yields <7,000 litres/cow. The results indicated that the management of higher-yielding herds (unlike lower yielding herds) were less concerned about either targeting a specific calving season or achieving a tight calving pattern with a longer period allowed to ensure cows conceived. Therefore, within these herds to achieve satisfactory conception rates a longer calving index is an acceptable part of the management strategy.

The occurrence of diseases can differ between systems and Washburn *et al*. (2002) reported that cows housed on TMR diets had 1.8 times more cases of clinical mastitis and increased culling rates compared to cows in pasture-based systems. The authors concluded that the higher yields of the cows on TMR diets and greater loss of body condition resulted in poorer fertility, with the increased culling rates attributable to both infertility and a higher incidence of mastitis.

Adequate minerals in the diet are an essential factor in maintaining herd health, irrespective of the calving season. Dairy cow rations during the winter period usually includes an added mineral supplement either via the purchased concentrates, from minerals added to the total mixed ration or from a mineral trough providing *ad libitum* access. Some recent studies have suggested that in relation to some minerals (e.g. phosphorus), supply may exceed the cow's requirements, leading to unnecessary feed costs and potential environmental losses. Minerals added to the concentrate or the TMR ensures a steady mineral supply providing intakes from the latter feeding method are maintained at consistently high levels. For the grazing cow not receiving concentrates there is an increased risk of mineral deficiency in fertilised pastures. In re-seeded leys with mixed species (grass/clover /herbs) and also when permanent pastures are grazed the available mineral content will be potentially higher but for the spring-calving cow producing high yields there is a risk of mineral deficiencies that may result in post-calving problems and poor conception rates (Jacklin, 1993).

5.2. The influence of variations in the reproductive efficiency of the herd on achieving the target calving period

Regardless of the calving pattern in an individual herd the financial state of a dairy enterprise will be influenced by the level of reproductive efficiency due to the effect of fertility on milk yield/cow, herd replacement rates and culling rates. The recent increase in the genetic merit of cows has resulted in infertility being a major and increasing factor in dairy herds (Oseni *et al*. , 2003). Even in well managed USA herds fed TMR diets throughout the year the attainment of high rolling average yields of 10,000 kg led to calving intervals of 410 days or 13.8 months (Allen, 2003). While this extended calving interval may be acceptable in herds where the quality of feed is consistent throughout the year and an even supply of milk production is required. For herds aiming for a tight calving within the same three specific months each year (e.g. September-November calving period for autumn calvers) the delay in conception creates problems in terms of diets and level of production.

In a modeling study of the cumulative yields of cows and first-lactation heifers in both the current and following lactations, Weller *et al*. (1985) reported that optimal milk output per cow was achieved when conception occurred between 98 and 117 days post calving, resulting in a calving index of 381-400 days. Analysis of separate data for both the first-lactation heifers and cows showed optimal conception for the heifers between 91-105 days post calving compared with 61-75 days for cows. Irrespective of lactation number, conception <60 days had an adverse effect on yield.

As shown in the following table of calculated figures for cows in both spring and autumn-calving, any delay in calving will maintain satisfactory conception rates and high yields/cow but increasingly move a higher proportion of cows in the herd out of the period (particularly for spring-calving herds) when optimum milk production/cow can be achieved, unless the quality of diet can be maintained. In the case of late calvers in a spring-calving herd this is likely require extra concentrate feeding and possibly extra conserved forage to achieve high feed DM intakes and a diet with an adequate energy density. Other disadvantages need to be considered, including the rearing of replacements with a diversity of birth dates during the year. If replacement heifers then calve at three rather than two years old, it is unlikely that the 6% extra milk that is produced, irrespective of breed (Poole, 1984), will compensate for the extra costs of keeping a non-lactating animal for an extra period of time beyond 24 months.

Table 1: Examples of the effect of delayed conception on the calving pattern within different herds (assumes 285-day pregnancy)

	Herd target calving period	Actual calving period	Post-calving days to conception	Next calving date	Calving index
1. Spring-calving herd	01 Feb – 31 Mar				
A: Regular breeding cows		01 Feb – 31 Mar	80	01 Feb – 31 Mar	365
B: Cows with delayed conception					
- Year 1		01 Feb – 31 Mar	120	10 Mar – 10 May	405
- Year 2		10 Mar – 10 May	120	11 Apr – 11 June	405
C: Cows with late conception					
- Year 1		01 Feb – 31 Mar	150	12 Apr – 11 June	435
- Year 2		12 Apr – 11 June	150	20 June – 20 Aug	435
2. Autumn-calving herd	01 Sept – 31 Oct				
A: Regular breeding cows		01 Sept – 31 Oct	80	01 Sept – 31 Mar	365
B: Cows with delayed conception					
- Year 1		01 Sept – 31 Oct	120	10 Oct – 10 Dec	405
- Tear 2		10 Oct – 10 Dec	120	19 Nov – 19 Jan	405
C: Cows with late conception					
- Year 1		01 Sept – 31 Oct	150	10 Nov – 09 Jan	435
- Year 2		10 Nov – 9 Jan	150	19 Jan – 20 Mar	435

5.3. The influence of the month of calving on milk production and fertility

5.3.1. The relationship between calving month and lactation yields

An examination of lactation curves in relation to the month of calving shows a major effect of diet on the level of total milk production. For example cows calving in late summer at pasture often show relatively lower peak yields and a steeper decline post-peak, than cows calving in the late autumn period and fed full winter diets from calving onwards (Chamberlain & Wilkinson, 1998). Therefore, achieving efficient milk production from cows calving when either herbage availability or quality are low is more challenging and requires both extra labour input and supplementary feeding. As shown in Figure 2, spring calvers have a different shaped lactation curve to autumn calvers, with autumn calvers benefiting from a 'second peak' in the spring (SAC, 2003).

Both Amies (1981) and Poole (1984) studied the influence of the month of calving on the total lactation yield of UK dairy cows and as shown in Table 2 they found large differences occurred between cows calving in different months. The data used by both authors included all breeds, with the British Friesian the dominant breed (86%). The yields ranged from 4,227 (Jersey) to 7,169 kg (Holstein), with the highest individual cow yield of 17,282 kg produced by a British Friesian with a lactation length of 305 days and a calving interval of 341 days. Amies (1981) stated both forage quality and availability and the ability of the cows at certain stages of lactation to respond to changes in the quality of the diet, particularly during the early lactation period, may have influenced the differences between the performance of cows' calving in different months. Also total milk yield was influenced by lactation length and cows with a calving interval of 330 days had a lower yield than those with an index of 370 days.

Figure 2: The difference in the shape of the lactation curve of autumn and spring-calving cows

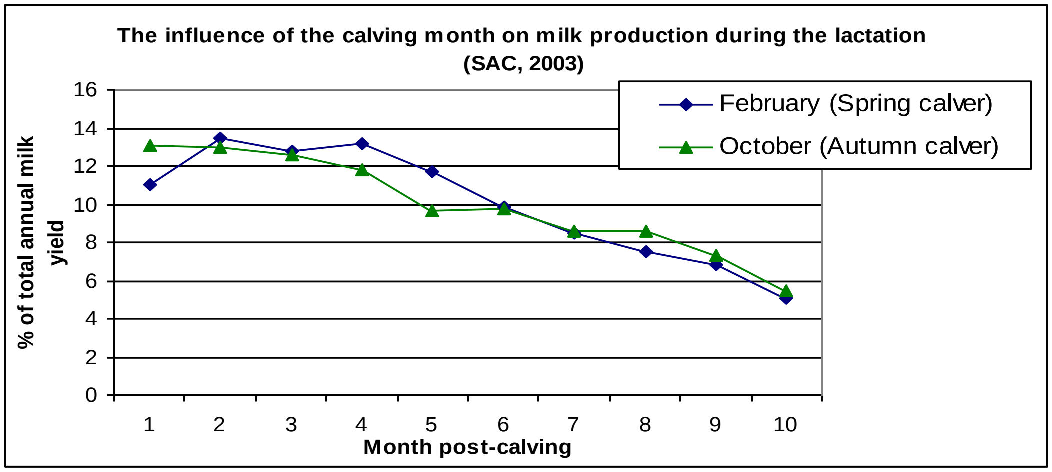


Table 2: The effect of the calving month on total lactation yields of UK dairy cows.

	Ref: Amies (1981)	Ref: Adapted from Poole (1984)	
Month of calving:	Milk yield index (July = 100)	Milk yield index (July = 100)	Lactation yield (kg)
January	111	105	5,642
February	108	103	5,530
March	105	104	5,580
April	104	103	5,507
May	102	102	5,455
June	101	101	5,383
July	100	100	5,353
August	104	101	5,396
September	109	103	5,523
October	112	107	5,704
November	114	108	5,808
December	113	109	5,857

Analysis of the effect of the month of calving on lactation yield was also studied in Washington, USA by Annis *et al.* (1959), including comparing the differences between three different breeds (Guernsey, Holstein and Jersey) and the results are shown in the table below. Differences between the calving month in the yield of milk and milk fat were 5.7 & 4.3% in Holstein cows and 7.7 & 5.7% in both the Guernsey and Jersey breeds. Although these differences in production between the months of calving are smaller than the range reported by Amies (1981) and slightly lower than those published by Poole (1984) the differences were significant.

Table 3: Correction factors for each calving month in the prediction of the 305-day lactation yields of three different breeds in USA dairy herds (Ref: Annis *et al,* 1959)

Breed: Month:	Guernsey	Holstein	Jersey
January	0.97	0.99	0.98
February	0.97	0.99	0.99
March	0.98	0.98	0.98
April	0.96	0.99	0.98
May	1.00	0.99	0.99
June	1.04	1.02	1.02
July	1.03	1.04	1.03
August	1.04	1.03	1.03
September	1.04	1.01	1.02
October	1.01	1.01	1.00
November	0.99	1.01	1.01
December	0.99	1.02	1.02

Analysis of the relative merits of calving cows within a specific month or short-time period may show that any differences that are associated with the month of calving, for example differences in the average calving index or ratio of lactating to non-lactating days (e.g. a short lactation followed by a longer than 60-day dry period), would have other effects, including changing the relative rolling average milk yield to lactation yield ratios and also the total milk output/ha. Higher milk yields in a specific month may be correlated to a longer period from calving to conception. It is also important to note that the current UK herd has >90% Holsteins whose genetic potential and, therefore, both their nutrient demand is higher and the average calving interval often longer in most herds when compared with herds in the pre Holstein-dominant dairy industry. The month of calving for these cows may be even more critical than for those cows included in the Amies (1981) and Poole (1984) reports and one could conclude that when adverse factors occur in specific months (low silage quality, limited herbage availability, very high-forage diets, severe weather following turnout etc) the influence of the calving season will be even greater on both the total length of the lactation and total milk lactation yield.

In a review of the results from studies analyzing the effects of the calving season on herd milk production, Garcia & Holmes (1999) concluded differences in the type of management system (e.g. 12-month housing on TMR versus milk production primarily from grazed herbage) had a greater influence on total milk production and the shape of the lactation curve than the month of calving. Annis *et al.* (1959) also concluded that for dairy farms in Washington, USA with a relatively moderate climate, where extreme temperatures were not a factor, changes in the type and availability of diet rather than the month of calving was the primary reason for differences between the production of cows in both total milk and milk fat. For example these results showed a marked influence on the change from silage-based rations to grazed herbage on the shape of the lactation curve and persistency of production during lactation.

5.3.2. The relationship between calving month/season and fertility

In any calving season the ability to get cows back in calf is an important factor, both economically and in relation to management when a tight calving pattern is required to ensure the target calving season is maintained from year to year.

Using the ADAS Datamate records of 300,000 cows Harrington (1995) studied the influence of the month of calving on herd fertility and found that the conception rates only varied between 45 and 52%, with the lowest rates recorded from cows calving in the April-May period. He suggested the low conception rates were attributable to poor submission rates and may be due to heat stress when temperatures reach >21^{0}C that result in inactivity by the cows and inhibition of bulling. The table below shows both the submission rates and conception rates recorded from the 300,000 cows.

Table 4: The effect of the month of calving has on submission rates and conception rates (Harrington, 1995).

	1st cycle submission rate (%)	Conception rate (%)
January	66	48
February	64	47
March	60	47
April	60	46
May	58	45
June	59	48
July	61	49
August	70	52
September	72	52
October	70	48
November	66	47
December	65	46

The performance of the Holstein Friesian (n=240, peak milk yield 30.33 litres) and Jersey (n=176, peak milk yield 18.41 litres) breeds managed within one large commercial herd (Simpson, 1998) was studied in relation to the effect of the season and month of calving on reproductive efficiency. Cows were housed from the start of September to the end of April and from May to August they grazed for half of the day and were fed a complete diet for the rest of the day. Differences between breeds in the average number of days from calving to conception were small (Holstein Friesian 118.4; Jersey 116.1), however, the number of serves per conception were significantly higher (2.22 v 1.81) in the Holstein Friesian cows. As shown in the following table the number of days to both 1st oestrus and 1st service were highest for cows calving in the spring. Calving cows in the spring, summer and winter markedly increased the number of days to conception compared with cows calving in the autumn period. Winter-calving Jersey cows had a long delay (145 days) between calving and conception and the author suggested this may be due to low conception rates and possibly higher embryo losses.

Table 5: The number of days from calving to 1st oestrus, 1st service and conception (Ref: Simpson, 1998).

	Days to 1st oestrus	Days to 1st service	Days to conception
Holstein Friesian			
Spring	88.0	97.1	126.7
Summer	68.2	74.2	128.2
Autumn	50.2	63.6	93.2
Winter	55.9	72.4	131.3
Jersey			
Spring	62.2	84.4	126.4
Summer	77.2	87.5	128.0
Autumn	45.2	75.0	93.5
Winter	76.5	95.7	145.4

Browne *et al*. (1993) also reported that despite similar or higher submission rates significantly, lower pregnancy rates were recorded with summer calvers (55-70%) compared with cows calving on the winter period (85-92%). The authors emphasized the importance of management practices in minimizing the risk of high embryo losses following insemination, including avoiding excessive disruption when cows move from grazing to housing, avoiding major changes in the diet and ensuring the appropriate body condition is maintained during lactation. The results recorded at Gelli Aur College has shown that a spring-calving herd of Holsteins can achieve milk yields of 5,040 litres from 0.36 t of concentrates/cow but to maintain a tight calving pattern conception rates suffer (Griffiths, 2001).

5.4 The importance of the dry period

5.4.1 Management in the dry period

Irrespective of the calving season the dry period is a critical time for the dairy cow and studies have shown that the level of nutrition in the dry period can influence performance post-calving. Over-feeing in the 7th and 8th months of pregnancy lead to problems at calving, including large calves (Whittaker (2002). However, Whittaker (2004A) found that in the 10-14 day pre-calving period 35-57% of cows had an energy deficit and 15-21% of the cows were short of rumen degradable protein (ERDP). He suggested that underfeeding during the dry period may be one of the factors linked to declining conception rates in UK dairy herds due to longer times to first heat, less obvious signs of oestrus, lower conception at first service and above normal embryo losses. Whittaker (2002) suggested that during this critical period cows should be fed the same type of ration both before and after calving to avoid an additional stress factor at this critical time. On any dairy farm it is easy to concentrate on the management strategy for the milking cows, with less attention given to their dry cows. A balance has to be met between underfeeding and overfeeding that leads to problems at calving and Whittaker (2003) suggested cows should be given the opportunity of eating 12-15 kg of feed DM/day. Whittaker (2003) suggested a cow should be dried off at a condition score of 2.5-3.0 and maintain the same score until calving. When planning a change in the calving pattern of a herd the question needs to be asked – can the dry cows be well managed either during the grazing period (e.g. autumn calvers) or during the winter period on silage diets (e.g. spring calvers)? Grass quality is low in September and October and both Amies (1981) and ADAS (1987) suggested autumn-calving cows should be fed silage-based diets pre-calving as this is either the primary or whole component of the diet post-calving. One disadvantage of calving cows either in the summer or early autumn periods is the increased risk of summer mastitis. Whittaker (2002) reported that milk fever was also a risk for dry cows during the spring period, with the mineral content varying between pastures.

5.4.2 The influence of the length of the dry period on lactation yields

To maintain a tight calving pattern some cows in a high-yielding herd with excellent fertility may have to be dried off while still producing high daily milk yields. Conversely spring calving cows in a poorer growing season may lack milk persistency after peak yield is reached, leading to a short lactation and a long dry period. This raises the question – does the length of the dry period affect yield in the subsequent lactation? Irrespective of the calving pattern of the herd the dry period will also affect performance and Poole (1984) reported that although the highest yields were produced from cows with a 48-day dry period, analysis of the data by grouping cows into different yield categories showed the highest yields of milk, milk fat and milk protein were recorded when the dry period lasted between 50-90 days. Poole (1984) also reported that cows with an excessively long dry period (150 days) had a lactation length that was 17 days shorter than cows dry for 60 days, with the highest yield produced by a cow with a dry period of only 48 days.

In the USA the average milk yield per cow is 8,000 kg/year, with some herds achieving 12,000 kg/cow (Schingoethe, 2002). Schingoethe analysed the performance of dairy cows in relation to the length of the dry period and as shown in the following table he reported a negative effect on long dry periods between lactations, with a sharp decline when the dry period is >70 days. He concluded that long dry periods and lower yields may lead to excess body condition and a higher number of problems at calving. However, the results from the study do not indicate either the length of the subsequent lactation or the reproductive efficiency in relation to the length of the dry period.

Table 6: The effect of the length of the dry period on milk production in the next lactation.

Length of dry period (days)	Lactation yield (kg)
<39	7,998
40-49	8,316
50-59	8,375
60-69	8,106
70-79	7,852
80-89	7,473
>90	7,197

5.5 The influence of the diet on milk yield, milk quality and herd fertility

Maximum intake of a high-energy diet is essential for the dairy cow during the early lactation period and a failure to provide an adequate diet has been found to increase the risk of metabolic disorders, reduced fertility and both a high milk fat to protein ration and milk protein values <3.0%, leading to changes in the calving pattern of the herd (Buckley *et al*., 2000; Loeffler *et al*., 1999; Heuer *et al*., 2000; Fahey *et al*., 2003). However, in the majority of UK herds, where the genetic potential of the cows has increased and outstripped intake capacity, it is inevitable that there will be a degree of negative energy balance in early lactation that potentially influences the health and fertility of the herd (Thomas *et al*., 1999). Therefore, a crucial factor in deciding on the calving season is the need to match as closely as possible the nutrient requirements of the cow with the best quality feed available. This is particularly critical for two groups of animals: (a) cows in early lactation when an energy deficit is normally recorded for all cows and (b) cows being fed high-forage diets as the flexibility to balance any nutritional deficiencies with sufficient quantities of suitable concentrate feeds are more limited. The higher the potential milk yield of the cow, the greater the risk of a large deficit between energy requirement and feed energy supply (Oldham, 1995). Failure to supply adequate energy can result in lower milk persistency during lactation, the production of lower quality milk, sub-clinical ketosis, delayed conception and increased culling rates when a tight calving pattern is to be maintained.

In a study of dairy cows producing lactation yields from 3,500 to 10.500 kg, Mee *et al.* (1999) found that increasing milk yield per cow was correlated to declining herd fertility. However, the correlation between milk yield and herd fertility is influenced by other factors, including the type of management systems and nutrition during the early lactation stage. The influence of the type of diet was clearly shown by Macmillan *et al.* (1996). They concluded that provided balanced diets are fed the magnitude of the negative energy balance of high-yielding autumn-calving cows fed winter rations may be less than for lower producing spring-calving cows in herbage-based systems which fail to satisfy their potential total and energy intakes under competitive or inadequate grazing conditions.

Irrespective of which calving pattern is selected for the individual herd some problems may occur. Whittaker (2004A) reported that when metabolic profiles were evaluated only one third of high-yielding cows had a satisfactory energy status in the 10-20 day post-calving period. Whittaker stated that the main reason for a poor energy balance was the failure to achieve satisfactory feed intakes, not because of the energy content of the diet.

Changes in milk composition have an effect on the processing characteristics of milk and either moving the calving pattern or aiming for block calving can significantly influence the average composition of the milk supplied to the factory (Garcia & Holmes, 1999), with autumn-calving cows having high milk fats in the summer and low milk fats in the winter and spring calvers having a reverse pattern. The fibre content of grazed grass ranges between 35-40% (Dillon & Stakelum (2000). A dairy cow requires 40+% fibre in the diet, below this figure milk fat starts to decline (Phillips, 2001).

In a comparison of autumn and spring- calving cows fed TMR (62.5% silage) and grazed herbage + 6.9 kg/cow of concentrates, the overall milk yield was 11.1% lower from the spring-calving cows (White *et al*., 2002). In a factorial-design study both autumn and spring-calving seasons were evaluated in low and high-input systems (Logue *et al*., 1999; Thomas *et al*., 1999). The results recorded from the Holstein-Friesian cows and heifers are shown in the Table below. Autumn-calving cows and heifers in the high-input system produced +62.7 & +52.6% more milk compared with those in the low-input system. The yields of spring-calving cows and heifers in the high-input system were increased but the differences were less marked than for the autumn-calving groups (37.7 & 27.4%). The milk response (kg of milk/kg of concentrate) of the cows and heifers to the extra concentrate + 3-times/day milking in the high-input system were +2.65 & +2.01 kg (autumn calvers) and +1.60 & 1.05 kg (spring calvers). However, it is important to note that the differences between groups does not take into account any differences in forage intakes (both grazed and conserved) or forage quality. The authors stated that the critical point in both systems was the poor condition of spring calvers in the low-input system and the low yield of the spring calvers in the high-input system, both being associated with a weight loss >0.5 kg/day at 100+ days post calving.

Table 7: The effect of calving season, concentrate inputs and number of milkings per day on the performance of Holstein-Friesian dairy cows and heifers (Adapted from Thomas *et al*., 1999).

System type: Calving season:	Low input Autumn	Low input Spring	High input Autumn	High input Spring
Forage for grazing & conservation:	Grass/clover	Grass/clover	Fertilised ryegrass	Fertilised ryegrass
Number of milkings/day	2	2	3	3
Concentrates t/cow	0.502	0.502	1.989	1.989
Milk yield (litres):				
Cows	6,108	6,123	9,940	8,436
Heifers	5,513	5,509	8,415	7,018

5.6. The relationship between herd genetics and calving season

As shown in other sections of the review different calving patterns (e.g. spring, autumn) are often correlated with either low-input and more extensive pasture based systems or high input intensive systems that are reliant on higher concentrate inputs to sustain high milk yields. Therefore, the type of cow required for an individual system will vary depending on their genetic potential as large differences can occur between breeds, within breeds and between cross-bred cows.

The genetic merit of the majority of dairy cows has increased during the last twenty years, primarily due to the Holstein breed. While these cows have the potential to produce higher yields by greater partitioning of nutrients into milk, their efficiency of converting metabolisable feed energy into milk has not increased (Gordon et al., 2000). Therefore, to sustain higher yields these cows need to achieve high intakes of energy-rich forages and be fed concentrate supplements if their potential is to be met and the problems of negative energy balance, lack of milk persistency, low milk proteins, increased risk of ketosis and poor reproductive performance are to be avoided.

Washburn *et al*. (2002) reported both poorer fertility and an increase in the number of cases of clinical mastitis with higher yielding Holstein cows compared with lower yielding Jerseys. As shown in the following table Jerseys were more fertile and healthier irrespective of whether the cows calved in the autumn and fed TMR diets or they were managed on a pasture-based system.

Table 8: The relationship between pregnancy rate and the incidence of mastitis (Washburn *et al*., 2002).

	Pregnancy rate (%)	% of cows with mastitis
Holstein cows:		
Housed, fed TMR diets	52.8	51.0
Pasture-based diets	63.0	31.4
Jersey cows:		
Housed, fed TMR diets	75.7	34.6
Pasture-based diets	80.5	17.0

The relationship between calving season, diet and breed has been found to be important in grass-based systems of milk production (Dillon *et al*., 2003). They reported that high-genetic merit Holstein Friesian cows had a greater loss of body condition in early lactation, lower reproductive performance and reduced longevity compared with cows of the Montbeliarde and Normande breeds and also Holstein Friesian cows with lower genetic merit. The pregnancy rates for the different breeds were: High-genetic merit Holstein Friesian 74%; Lower genetic merit Holstein Friesian 87%; Montbeliarde 91% & Normande 92%.

In Ireland the normal practice is to feed 750 kg of concentrates to herds primarily producing milk form pasture-based systems, however, Shalloo *et al*. (2004) questioned whether this was the optimum level of concentrates to achieve maximum milk production. In a 3-year study they evaluated the influence of different cow genetic potential on three different milk production scenarios based on contrasting concentrate inputs in pasture-based systems and Holstein-Friesian cows of different genetic merit. During the 3-year study the sub-groups within the low and high genetic potential groups were fed 376 kg and 1,540 kg of concentrates per lactation. With both the low and high concentrate inputs the total lactation yields were higher from the high genetic potential cows (7,000 & 8,548 kg) compared with cows of lower genetic merit (6,599 & 7,076 kg), with the yield response to higher concentrate inputs more significantly higher with the high genetic potential cows. These results confirm those reported by Dillon *et al*. (2003) that dietary energy is a critical factor in the performance of a cow, regardless management system or calving season. The authors concluded that optimum production was achieved from either lower genetic merit cows fed a low level of concentrates or from higher concentrate inputs fed to cows with greater genetic merit.

In a factorial-designed experiment White *et al*. (2002) compared two dairy breeds (Holstein, Jersey) and feeding systems. They fed a TMR (62.5% silage) to autumn-calving cows of each breed with spring-calving cows of the two breeds grazing herbage and receiving 6.9 kg/cow of concentrates. The average milk yields of the autumn and spring calving cows were: Holstein cows - 8,560 v 6,901 kg ; Jersey cows 6,194 v 5,315 kg. Autumn rather than spring calving significantly increased yields by +24.0% from the Holstein cows and +16.5% from the Jersey cows. The authors concluded that despite the lower yields from spring-calving cows, when production costs were taken into account the system is competitive with more-intensive systems that are based on silage as the main forage.

As the above results show there is a need to consider the type of cow for different systems of milk production and calving pattern options, particularly in relation to feed energy supply in early lactation. This is supported by the work of Belyea & Adams (1990) that although higher genetic merit cows produced more milk than cows of lower genetic merit, the higher feed intakes and lack of improvement in the efficiency of feed energy conversion into milk lead to feed energy problems unless the appropriate energy-dense diets are fed.

5.7. The relationship between ambient temperatures and time of calving

Changes in the ambient temperatures can affect the performance of a dairy herd, particularly for cows calving in specific seasons of the year when they are producing high milk yields and need to breed. For example dairy herds in some USA states, following seasonal calving patterns and with peak production recorded in the spring and early summer months show adverse effects of increasing temperatures (Ray *et al*., 1992; Moore *et al*., 2004). As temperatures increase feed intakes are reduced, milk yields decline and reproductive performance is lower. The combined effects of increasing temperatures and humidity levels will also affect daily milk yield and the shape of the lactation curve (Garcia & Holmes, 1999). While these effects of climate are more pronounced in countries with more extreme weather, high summer or cold winter temperatures in the UK and other northern European countries are likely to also influence herd performance, either directly or indirectly (due to poorer herbage quality). Harrington (1995) suggested low conception rates can be linked to heat stress when temperatures reach >21^{0}C that result in inactivity by the cows and inhibition of bulling, Ray *et al*. (1992) reported heat stress problems when temperatures increased above 24^{0}C, Phillips (2001D) stated that conception was more difficult when temperatures reached 30^{0}C and when temperatures increase to >31^{0}C Bakke (2003) found that Holstein cows were less tolerant to the high temperatures than Jersey cows. During hot summers in the UK cows are vulnerable to heat stress that can lead to the negative effects on performance and high-yielding cows, due to be served to ensure the calving pattern of the herd is maintained, can be a potential problem due to reduced oestrus activity . It is not only high temperatures that can influence reproductive performance, cold winter temperatures have also been found to reduce oestrus activity (Blowey, 1999; Berka *et al.,* 2004), with conception rates falling when temperatures fall below 10^{0}C.

The relationship between calving season and fertility is not always attributable to differences in genetics or management factors but can be affected by environmental factors. Initial examination of data from dairy herds in different parts of the USA showed that a tight calving pattern led to poorer fertility and a period of 150 days between calving and conception compared with herds with an extended calving season and an average conception date of 141 days. However, further analyses shows delayed conception date was not correlated to stage of lactation, type of diet or high milk yields but were the result of either mating cows during periods of heat stress leading to reduced fertility or a management decision on different farms to delay the start of the service period and avoid mating cows during high ambient temperatures.

Poor performance due to climatic conditions not only reduces production but can reduce reproductive efficiency, leading to higher culling rates and the extra costs associated with bringing more replacements (homebred or purchased) into the herd (Garcia & Holmes, 1999).

6. CALVING PATTERN OPTIONS

Mee *et al*. (1999) stated that the calving pattern of a herd is dictated by a number of factors including the previous calving pattern, breeding policy for replacement heifers, culling strategy, stock purchases and reproductive performance. The decision to change the calving pattern can be achieved in three ways:

1. Move the calving date of the heifers
2. Manipulate the calving date of the current cows
3. Purchase new animals

Any change to the current calving pattern is likely to involve costs associated with a delayed first service date and a fall in income during the period when the changes are being made (Amies, 1981; Jalvingh *et a*l., 1993B). Moving the month of calving may also lead to a reduction in reproductive efficiency. The results from a survey of dairy farmers in Holland showed the most favoured option for changing the calving pattern of the herd was to move the calving date of the heifers entering the herd, rather than moving the calving date of the existing cows in the herd (Jalvingh *et al*., 1993B). A key question is whether it is more costly to delay the first-calving date of a heifer or extend the calving interval of cows within the herd. It is also important to note that changing the calving pattern will never involve the whole herd as a proportion of the herd will be culled each year due to mastitis, infertility, death etc.

6.1. Spring calving pattern

6.1.1. Reasons for selecting a spring-calving pattern

A spring-calving pattern has for many years been viewed as an option for reducing the cost of milk production and the gradual decline in profit margins from dairy herds has led to increased interest in producing milk cheaper and primarily from grazed herbage, rather than from silage-based diets (Dillon & Stakelum, 2000). New Zealand dairy farmers have led the way in showing how good production can be achieved under low-cost grazing systems. However, even though extended grazing systems have been successfully introduced on many UK dairy farms a number of factors need to be considered before the decision is made to move to milk production based primarily on herbage rather than silage-based diets during the early part of lactation. Theoretically producing milk from herbage rather than conserved forage is a viable system providing herbage quality is high, optimum intakes are achieved during the spring and summer months and effective grazing management leads to efficient feed conversion by the cow into milk. If these targets are achieved then feed costs will be lower, including lower concentrate inputs, when compared with cows calving in other seasons. However, as discussed below other factors influence the performance of the spring-calving herd and this system, although usually classified as ‘low input’, can be more challenging than many autumn-calving systems. Being able to achieve adequate herbage growth during the grazing season favours the wetter regions of the UK when herds calve in the spring (ADAS, 1985).

ADAS (1985) suggested a spring-calving herd could produce 60% of the total milk production in the April-September period with potentially 90% of the lactation yield produced from forage (grazed herbage, silage).

ADAS (1985) also stated that spring-calving herds required a shorter winter housed period and therefore less silage for the winter. However, this statement will not be applicable to many farms where the length of the winter will be dictated by the climatic conditions and soil type on the individual farm even allowing for the lower silage intakes of the late lactation/dry cows compared with those of autumn calvers in early/mid lactation.

Amies (1981) stated that unlike autumn calvers changing from silage to herbage-based diets, cows calving in the spring did not receive a boost in mid-lactation and were more likely to suffer from the adverse effects of declining herbage quality, leading to a shorter lactation length unless adequate extra feed supplements were fed. However, when diets were adequate, including high standards of grassland management, Amies (1981) suggested financial margins good be as good as those from autumn-calved cows but Street (1974) concluded that a spring-calving system is often dependent on low production costs due to the low milk price during peak production. The implications of providing extra feed (silage, concentrates) to sustain milk persistency and lactation length as the lactation progresses would increase costs that may be difficult to justify even though the response to concentrate supplementation is often greater in late rather than early lactation (Garcia & Holmes, 1999).

6.1.2. The influence of the calving month within a spring-calving season

Milk yield increases steadily after calving and Poole (1984) reported that peak milk yield was reached 60 days post-partum. Therefore, efficient utilisation of herbage for milk production from a spring-calving herd depends on ensuring cows are producing good yields at turnout, rather than aiming for calving date to coincide with the date for turnout. Feed intake is also lower immediately after calving and Vadiveloo & Holmes (1979) found peak intake was not reached until c.12 weeks post-calving. ADAS (1985) and Bird (2001) suggested that to maximise profit cows should calve in a 14-week block, even if this leads to buying in cows due to calve in February and selling those due to calve in May. A number of studies (Annis *et al*., 1959; Street, 1974; Garcia & Holmes, 1999; Mee *et al*., 1999) also reported benefits in calving cows during the February-April period, rather than from turnout onwards, with cows reaching peak yields when the grazing season commenced in May with the earlier calving leading to longer lactation lengths. ADAS (1985) reported benefits from calving cows in the January-February period compared with the March-April period with lactation yields increased by 22%, however concentrate inputs were markedly higher for the early calvers (700 v 150 kg/cow). Gracia & Holmes (1999) also stated that the disadvantages of a spring-calving pattern were the dependence on sufficient quantities of forage being available during early lactation (i.e. both pre and post-turnout). It should also be noted that forward planning to ensure cows calve within the February-April window will not always lead to turning cows out at the correct time as in some years abnormal weather conditions will lead to either a very early or a late turnout date, resulting in a below optimal fit between peak yields and grazing spring herbage of high quality.

In Ireland the bulk of milk is based on seasonal calving with output often constrained by legislated quota on one or more components in the milk, with herd fertility having a major affect on herd performance and profitability. The grazing season in Ireland extends from early March to late November and the farm model developed by Veerkamp *et al.,* (2002) showed an advantage in total milk yield, higher grass intakes and a lower silage requirement when cows calved in February compared with later calving cows (see table below). However, the yield of milk fat and protein were similar and the early-calving cows required more concentrates to balance the extra silage that would be fed. Key inter-related parameters affecting the output from the model included: yield per cow, milk quality, calving interval, culling rate, milk price, quota leasing, labour costs, stocking density and feed costs per kg of milk. The energy value of the grass was calculated as 12.3 (March) and 11.4 MJ/kg DM (November). The output from the model supports the results from farm trials that calving before, rather than around turnout date, can improve the level of milk production and reduce feed costs. However, between seasons changes in the quality of silage pre-turnout would adversely affect the early calvers and poor weather post-turnout may affect late calvers more than those past the first few weeks of lactation.

Table 9: Modeling the effect of calving month on milk production and the rations of cows with a 365 calving index (Veerkamp *et al*., 2002).

Month of calving:	February	March	April
Yields (kg/cow): Milk	5,880	5,760	5,700
Fat	215	217	213
Protein	194	196	193
Feed budget:			
Total intake (kg)	4,434	4,518	4,488
Grass intake (kg)	2,781	2,690	2,620
Silage intake (kg)	1,195	1,485	1,531
Concentrate intake (kg)	458	344	337
% ingredients in the annual diet:			
Grass	0.63	0.60	0.58
Silage	0.27	0.33	0.34
Concentrates	0.10	0.07	0.08

In addition to the modeling work on the relation between the calving date of spring-calving cows and herd performance, an on-farm study was carried out in Ireland by Dillon *et al.* (1995). In a 3-year experiment (see table below) they compared the influence of calving date and stocking rate on the performance of three spring-calving groups. The early calving groups (System A) had a mean calving date of 23 January and were stocked at 2.9 cows/ha. Two later calving groups with a mean calving date of 15 March were stocked at either 2.9 cows/ha (System B) or 2.6 cows/ha (System C). In Years 1-3 cows grazed during the day from 13, 19 and 4 March and grazed both during the day and night from 26, 27 and 19 March, respectively. Delaying calving date to coincide with the beginning of the grass-growing season reduced milk significantly ($p<0.05$) in all three years of the experiment, with no significant differences in the yields of milk fat and protein due to the better milk quality of the later calving cows. Reducing the stocking rate from 2.9 to 2.6 cows/ha for cows calving in mid-March (System C compared with System B) increased milk yield per cow significantly ($P<0.05$) in only one of the three years. Stocking rate had no effect on milk composition. In all three years of the experiment delaying the calving date (System B) resulted in lower live weights at the end of lactation ($P<0.05$). Satisfactory reproductive performance was achieved with all three groups.

Table 10: The effect of calving date on the performance of spring-calving dairy cows (Dillon *et al.,* 1995)

System: Mean calving date:	A 23 January	B 15 March	C 15 March
Stocking rate (cows/ha)	2.9	2.9	2.6
Average 3-year milk output:			
Yield (kg)	5,872	5,444	5,584
Fat (kg)	210	204	215
Protein (kg)	187	184	189
Fat%	3.60	3.76	3.87
Protein%	3.19	3.37	3.38
Average concentrates fed (kg/cow/year)	620	185	80
Average lactation length	307	304	210

6.1.3. Herbage intake and quality, milk quality and cow health

The first limiting nutrition factor for the high yielding spring-calving cow during grazing is feed energy (Kolver & Muller, 1998) and Dillon & Stakelum (2000) stated that differences between groups/herds of cows in average milk yield should be addressed by adjusting the stocking rates as higher yielding cows require higher intakes to meet their nutrient requirements. Therefore, at equal stocking densities these cows would be under greater pressure than those producing lower yields. Increasing the quantity of herbage available for grazing will benefit the cow in relation to allowing higher intakes and improved milk yields but will lead to a reduction in the efficiency of herbage utilisation (Tozer *et al*, 2004). A dairy farmer needs to ask what is the priority for the farm, output per cow or output per hectare as there is an inverse relationship between stocking rates and animal productivity with increases in stocking rates increasing output per unit area but decreasing output per cow (Tozer *et al*. (2004). A critical factor during the grazing season is the relationship between milk yields and stocking density. McMeekan & Walshe (1963) suggested that maximum milk output per unit area of land led to a reduction in the milk output/cow of 10-12%, compared with the yields achieved under a more lax grazing system.

The shorter lactation length of spring-calving cows may be caused by the declining herbage availability and quality as the season progresses and also the less favourable weather conditions during the autumn. In New Zealand cows calving in late winter/early spring to ensure the herd's feed requirements after calving coincide with the increased grass growth during the spring period. By late summer/early autumn when herbage supply is reduced cows in late lactation are dried off after 220-240 days (Garcia & Holmes, 1999), much shorter lactation lengths than those recorded in European spring-calving herds Shalloo *et al*. (2004). However, in a review of grazing studies Phillips (1989) reported that even in the favourable grass growing areas of northern Europe the intake of herbage declined by 11-19% in the autumn, with the herbage dead matter content increasing from 10% in the spring to 40% in the autumn and 20-30%,of the autumn herbage rejected because of faecal contamination. McMeekan (1961) reported that earlier calving was correlated to a longer lactation length as all cows tended to dry off at the same time in the autumn/early winter period, irrespective of when the cows calved in the spring. In Ireland Keene & Gleeson (1985) reported that the lactation lengths of cows in spring-calving herds were increased by calving in the January-February period, with peak yield achieved pre-turnout rather than in March-April when peak yield often occurs post-turnout.

Unlike recording the DM intakes from winter rations, measuring intakes of herbage during grazing is less accurate. Cows being continuously grazed or set stocked can be allowed sufficient herbage to avoid the risk of restricting intakes. In paddock or strip grazing systems the use of a rising-plate meter will provide an estimate of the available herbage prior to grazing. However, the relationship between sward height and the available herbage mass will vary both during the season and when cows change for example from a re-seeded ryegrass ley to permanent pastures or a mixed grass/white clover ley.

To gain the optimum intakes from the herbage an MDC study (MDC, 1999) showed that turning cows on to fresh pasture after the afternoon milking (rather than allocating new grass in the morning), led to a 5% increase in milk yields as grazing animals consume their largest meal just before sunset. Grass also has a higher content of DM and sugars later in the day, although the latter content will be dependent on the weather and number of sunshine hours. If milk persistency is to be maintained during lactation then good grazing management is critical. Spring grass will usually be high in digestibility, sugars and protein but low in fibre content, therefore, low milk fat values can occur unless a higher fibre feed is not only made available but also eaten by the cow.

In a model of autumn and spring-calving systems, Valencia & Anderson (200) concluded that the efficiency of grazing utilization was a key factor in the success of the latter system with 75% utilisation essential and farm factors (rainfall, soil type and vulnerability to poaching) key factors in achieving high efficiency.

Both Baker (1980) and Mayne *et al*. (1988) reported that compared with the yields obtained from grazing all cows in one group, milk output per cow could be increased by 10-26% by adopting a leader/follower grazing system. Milk yield per hectare was also increased in both trials. This system allows the high-yielding cows to select the best quality herbage with adequate herbage still available for the following group of lower yielders.

O'Brien *et al*. (1999) stated that provided spring-calving cows received an adequate plane of nutrition during lactation, high quality milk suitable for processing into cheese could be produced until November/early December or 275 days post calving. However, analyses of many milk samples showed declining quality during the autumn period from cows fed only 2 kg of concentrates at grazing, requiring early lactation milk from autumn calvers fed a higher quantity of concentrates (8 kg) to be added to the milk of the spring calvers to provide milk with satisfactory fat, protein and casein concentrations.

Spring grass can have a high protein content and although these diets will often lead to an improvement in the milk protein concentration, some studies have shown that a high-protein content in the diet (19+%) can reduce reproductive efficiency. Increased protein in the diet has been correlated to increased urea in the blood, an increase in the number of serves/conception and impaired embryo survival (Plym Forshell, 1994; Chamberlain & Wilkinson, 1998). Although other workers (Carroll *et al*., 1988) have not recorded any effects when diets with a protein content of 20% are fed this may be due to the composition of the protein, including the level of non-protein nitrogen. Therefore, the potential risk, irrespective of the calving pattern of the herd, when non-pregnant cows graze protein-rich swards of either fertilised ryegrass or grass/clover mixtures and do not receive any supplement of a high energy/low feed should be considered.

High-yielding cows (not only spring calvers but also late autumn calvers still producing high yields) are more susceptible to hypomagnesaemia (ADAS, 1985; ADAS, 1987; Chamberlain & Wilkinson, 1998) and a magnesium supplement (e.g. included in the concentrate or water trough) is often necessary to prevent problems occurring. Spring herbage, especially when rapid growth occurs and/or when high quantities of N-fertiliser have been applied, often has low magnesium contents and even when calcined magnesite was fed Rae & Reeve (1985) reported that the blood magnesium levels were low in some spring-calving cows grazing ryegrass leys and fed no other concentrate supplement. However, in organic systems where grass/clover swards are grazed there appears to be minimal problems and may be attributed to the higher magnesium content of the clover plants (R.Weller – unpublished data).

European grazing studies have been primarily on fertilised ryegrass swards with intakes on grass-only diets reaching a maximum of 18.0 kg DM/day. In the USA where cows grazed non-ryegrass leys (e.g. cocksfoot + smooth brome grass) intakes higher intakes have been recorded and Bargo *et al*. (2002) reported intakes on grass-only swards increasing from 17.7 kg/day (2.9% of body weight) to 20.5 kg/day (3.4% of body weight) when the herbage allowance was increased from 25 to 40 kg DM/cow/day or to 50% above the actual intakes. However, it should be noted that at this level of herbage allocation (i.e. lax grazing) the efficiency of herbage utilisation would be low and the cost of feed per unit of milk significantly higher – raising the question of how viable this practice would be on a commercial farm when other variable costs and overheads are included in the cost of production.

6.1.3.1 The influence of legumes in grazed pastures

Spring-calving herds are well placed to benefit from grazing grass/white clover pastures, including both reseeds and permanent pastures. Milk protein levels are often significantly increased when cows change from silage-based diets to grazing grass/white clover leys and are often associated with both increased intakes and the higher energy value of the grazed herbage. Increases in the milk protein content of 0.3-0.4% have been recorded at IGER Ty Gwyn when the dairy herd is turned out to graze on grass/white clover leys. The protein content of the milk will also increase during the grazing season as the protein content of both the grass and white clover in the sward increases (Weller & Cooper, 2001). By early July the protein in the herbage is significantly above the cow's requirements and will reach 25% by the autumn, potentially leading to poor protein utilisation by the cow. For the high-yielding cow receiving a concentrate supplement that has a high energy/low protein value the diet will be balanced, however, for cows not being fed concentrates extra feed energy will be used inefficiently to excrete the surplus protein. The buffer feeding of a lower protein forage also improves the protein to energy ratio of the diet but unless either herbage availability is low or the palatability and quality of the forage very high (e.g. well preserved maize silage), cows are unlikely to consume significant quantities of the forage. Low milk fat contents can also be a problem when cows graze clover-rich swards that are low in fibre content and work at IGER (Weller – unpublished data) has shown milk fat % declining to 3.6 during the mid-summer period. The risk of bloat can be minimized by ensuring hungry cows never have access to clover-rich pastures and by ensuring sufficient long fibre is available.

6.1.4. Forage-only diets for spring-calving herds

The output of milk has been measured in spring-calving cows fed all-forage diets. Cows and heifers calving primarily in the December to February period were fed diets based on 100% high-quality grass silage (DOMD 697 g/kg) for an average of 83 days until turnout, recording DM intakes of 12.5 kg/day and yielding on average 21.5 (cows) and 16.1 kg/day (heifers) of milk. With the exception of a small quantity of a calcined magenesite supplement no concentrates were fed either before or after turnout. Average full lactation yields were 4,725 kg for cows and 3,998 kg for heifers during average lactation lengths of 278 days. Reproductive performance was reported as satisfactory with a pregnancy rate of 90.9% recorded from 1.9 services/conception and a calving index of 366 days. Fertiliser inputs were 450 kg of N/ha , stocking rate 2.5 cows/ha, UME/cow 47.5 GJ and UME/ha 118.8 GJ. These results were recorded some years ago with British Friesians and the authors concluded that the quality of both the silage fed prior to turnout and the quality of the herbage available for grazing needs to be high in this type of system. They suggested that benefits would be gained from feeding a small quantity of concentrates in relation to increasing financial margins due to both the higher yield per cow and increased stocking density. The feeding of concentrates would also reduce the overall fixed costs/ha but the cost per tonne of concentrates would be an important factor in deciding the appropriate level of concentrate to feed. Recent studies (Oldham, 1995) show that higher genetic Holstein cows managed in this type of system where all-forage diets are fed would be more vulnerable to a higher energy deficit during the early lactation period, leading to potential problems of lower milk persistency, poorer milk quality and delayed conception. Darwash *et al.* (1997) studied the fertility of British Friesian cows and also reported poorer reproductive efficiency with spring-calving cows with the commencement of luteal activity 1.21 times longer than for autumn-calving cows

When grazed herbage is the sole feed the genetic merit of the cow has been found to be of increasing importance. A comparison on an all-herbage system in New Zealand between local strains of Holstein compared and imported Holstein heifers from Holland with a higher genetic merit showed the latter were unable to maintain adequate body condition scores on the all-forage diet (Kolver *et al*., 2000). Unfortunately the effects of the low body condition scores on reproductive performance including conception rates and days open were not reported in this study. However, a deficit of dietary energy has been found to delay the onset of normal ovarian activity and also increase the risk of the embryo failing to implant in the uterine wall and surviving into the early stages of pregnancy (Butler & Smith, 1989).

6.1.5. The role of concentrate supplementation in spring-calving systems

Concentrate supplementation is an essential management tool in many, but not all, pasture-based systems. Concentrates are used primarily for spring-calving herds but also are fed to high-yielding cows that calved during the late autumn/winter period. The potential output from a spring-calving system can be high and Ramsbottom (2003) reported that spring-calving cows can produce 6,500 kg of milk, from a concentrate input of only 340 kg/cow with grazed herbage providing 70% of the total annual ration (but only 50% of the total feed costs).

Depending on both the milk and concentrate prices, milk yield response to concentrates in the short term determines whether concentrate supplementation is profitable. However, other longer-term factors also need to be considered in any economic evaluation, including increases in the stocking density on the farm, improvements in pasture management and herbage utilisation, positive effects on body condition scores, fertility, increases in lactation length and positive effects on milk composition (Bargo *et al*., 2003).

In a review of published results on the feeding of concentrates to grazing dairy cows Bargo *et al*. (2003) concluded that milk production increased linearly as the amount of concentrates increases from 1.2 to 10.0 kg DM/day. However, Meijs & Hoekstra (1984) suggested that feeding spring calvers a high quantity of concentrates after turnout is likely to prove unprofitable due to reduced grass intakes and they reported a maximum response of 0.4 kg of milk/kg of concentrate. However, in a further review of the published data on the response of grazing cows to concentrate supplementation Dillon & Stakelum (2000) reported large variations between studies. For cows producing 15-25 kg/day the milk response (kg milk/kg concentrate) ranged from 0.32 to 0.50, while high-yielding cows recorded more efficient responses up to 1.12, similar to the overall milk response of 1.0 reported by Bargo *et al*. (2003). The milk yield response to concentrate supplementation and financial returns are dependent on other factors, including herbage quality and availability and the price of the concentrate supplement.

Kolver *et al*., (2000) questioned the role of high-genetic merit cows in all-grass system and the results from CEDAR and Moorepark (Beever, 2003; Dillon *et al*, 1997) indicate that grazed herbage is sufficient for milking cows producing only up to 25 kg/day with supplementation required above this level of milk yield, including feeding 6-7 kg of concentrates to a cow yielding 40 kg. For the high-genetic merit cow Mayne (1996) suggested that a cow producing 32.5 kg of milk/day would need to consume a high herbage intake of 18.7 kg DM/day to maintain a similar energy balance to that of a medium merit cow producing 25.0 kg of milk/day and consuming 15 kg of herbage DM/day. Achieving very high intakes from these cows is likely only to be achieved from a lower stocking rate than would be implemented with lower-yielding cows. Even under ideal grazing conditions the maximum intake of a cow will be under 19.0 kg DM/day (Meijs & Hoekstra, 1984; Kolver & Muller, 1998), sufficient for the cow yielding 25 kg but not in feed energy terms sufficient for those yielding >30 kg/day. As shown in the following table Mayne (1996) suggested the following concentrate feeding levels but only if adequate herbage allowance of 25 kg DM above 5 cm was available for grazing. For this system to be successful it will require excellent management of the grazing swards and adequate quantities of herbage for grazing. This may require a willingness to use an area put aside for silage should grass growth fall sharply

Table 11: Suggested concentrate feed levels for high-yielding cows in early and late season with a high herbage allowance of 25 kg DM/cow/day above 5 cm (Mayne, 1996).

Period:	Mid May			Late August	
Target milk yield (kg/day):	25.0	35.0	40.0	25.0	35.0
Potential production from grass only (kg milk/day)	27.0	29.4	30.9	20.0	24.5
Supplement feed level (kg DM/cow/day)	0	3.9	6.3	3.5	7.3

6.2. Autumn calving pattern

The majority of cows in an autumn-calving herd will calve in the August-November period with many herds relying on greater usage of concentrate feeds in the total ration compared with herds managed in other systems. Compared with the more limited management options available with spring-calving herds, where grazed herbage is the main feed, the autumn-calving herd can be managed in a number of different ways. These range from a low-input, easy feed system based on self-feed silage and the feeding of a low level of concentrates to an intensive system that relies on TMR diets to ensure high yields are produced from the herd. Key advantages for herds calving in the autumn are the benefit of higher lactation yields, a more favourable milk price and a spring flush in yield during late lactation (ADAS, 1987). However, this is balanced by the relatively higher cost of feed inputs per kg of milk produced as the cost of producing silage is higher than for grazed herbage and the feed quality per kg DM lower.

ADAS (1987) stated that the highest gross income from a dairy enterprise is likely to be earned by the autumn-calving cow as she is in full milk during the period of highest value and is able to produce a final flush cheaply in the following spring. However, the recent changes in milk contracts, with prices influenced by the deviations from the monthly agreed milk totals (Nix, 2004) add in another factor when gross income figures are being calculated. Although lower input spring-calving systems may achieve higher gross margins per litre, high yielding autumn calving herds can have lower total costs per litre due to fixed costs being spread over a larger output (ADAS, 1985). An autumn-calving herd has the potential to adapt to the end-of-year quota situation during the late winter period, including either increasing or decreasing daily milk production. Options include either increasing concentrate inputs to boost milk yields prior to turnout or reducing concentrate inputs to reduce yields. Some farms may consider buying in animals to boost yields but this option needs careful consideration, particularly in relation to costs and the risk of bringing in disease problems. In an earlier study, where the output from a model of different dairy systems was evaluated (Street, 1974) the author concluded that where a high stocking density was essential an autumn-calving herd was likely to be the only viable system. However, milk prices were calculated based on only seasonality payments and the model assumed a high level of concentrates would be purchased. Therefore, the model does not look at the wider implications that are associated with purchasing concentrates (e.g. whole-farm nutrient budgets on farms growing the concentrate feeds, the environmental effects of a high stocking density, including meeting new legal requirements in relation to nitrate vulnerable zones, slurry storage capacity).

Bar-Anan *et al*. (1985) reported that better reproductive performance was also achieved with cows that had lower peak yields but higher total lactation yields and a greater yield persistency during lactation due to a smaller negative energy balance. In a review by Garcia & Holmes (1999) autumn-calving cows were found to have lower peak yields than those calving in the spring but higher milk persistency during lactation. They also had higher annual yields of milk and milk solids than spring-calved cows, primarily due to a ‘second’ peak at turnout time (attributable to greater feed quality and availability), longer lactations and higher daily milk yields in late lactation.

Provided balanced diets are fed the negative energy balance of high-yielding autumn-calving cows fed winter rations may be lower than lower producing spring-calving cows in herbage-based systems which fail to satisfy their potential intakes under competitive or inadequate grazing conditions (Macmillan *et al.,* 1996). The importance of balanced diets is clearly shown from the results reported by Gordon *et al*. (2000) in a comparison of high forage (HF) and high concentrates (HC) systems. During the 132-day period of housing autumn-calving cows were fed grass silage with the level of concentrate supplementation either 781 (24% of the total intake) or 1,930 kg (56% of the total intake). High milk yields were produced in both systems during the 132-day winter period on silage diets (HF 3,926, HC – 4,475 kg) and during the 305-day lactation period (HF – 7,854, HC – 8,640 kg). Not only were the yields lower from the HF group (13.3%) when the silage diets were fed, both the body condition score (2.2 v 2.5) and back fat thickness (4.6 v 5.2 mm) were lower and attributed to both the lower intake of cows fed the HF diet and the lower ME density of the HF diet (11.06 v 11.60 MJ/kg DM).

Critical factors in the management and profitability of the autumn calving herd are the conservation of high quality silage, achieving high feed intakes, feeding the appropriate ration for the different stages of lactation and good heat detection to ensure the reproductive efficiency of the herd is maintained (ADAS, 1987). Even with cows calving within a relatively short time period the division of cows into different groups, based on milk yield, may be desirable to ensure concentrate feeding is efficient and the maximum output of milk from forage is achieved. Heat detection during the days when the daylight hours are lower and temperatures low can be more difficult as the oestrus period may only last a few hours (often at night) (ADAS, 1987). Although the quality of the conserved forages (e.g. silage) fed during the winter period are generally lower in the UK than the quality of grazed herbage (Holt-Martyn, 2003) there are beneficial effects from feeding these diets. For example the quantity of silage being fed can either be measured via the weigh cells on a mixer wagon or volumetrically by measuring the density and rate if usage of silage from the clamp. Unlike the grazing period herd intakes during the winter will be less influenced by weather conditions and unless the quality of the silage varies differences between daily intakes may be smaller. However, intake is influence by the type of feeding systems and reductions in silage quality. The following correction factors for calculating the potential feed intakes from different feeding systems have been suggested by ADAS (1987) and Chamberlain & Wilkinson (1998):

Table 12: Correction factors to estimate the total DM intake from different feeding systems (ADAS, 1987; adapted from Chamberlain & Wilkinson, 1998)

System:	Correction factor	*Comments*
TRM/Complete diet	*1.2-1.3*	*Increases in intake depend on the quality of the diet. Diet needs 35+% forage, DM% of 40-50%*
Mixed forages	*1.0-1.05*	*Depends on the how complementary the different forages*
Self-feed silage	*0.9-0.95*	*Depends on width of silo face*
Electric fence at silage face	*0.8-0.9*	*Greatest depression in short-necked animals (e.g. heifers in the herd)*
Poorly preserved silage	*0.7-0.9*	*Influenced by the forage: concentrate ratio*
Out-of-parlour feeders	*1.05-1.11*	*Influenced by the quality and availability of the available forage*
Week of lactation	*0.66-1.0*	*Increasing from Week 1 (0.66) to Week 12 (1.0)*

Increasing the concentrate inputs can lead to higher milk yields and the relationship between different levels of concentrate inputs and expected milk output (ABC, 2004) is shown in the following table.

Table 13. Predicted milk yields from different concentrate inputs in autumn-calving herds (ABC, 2004).

Concentrate inputs (t/cow)	1.57	2.04	2.56	3.15
Predicted milk yield (litres/cow)	6,400	7,400	8,400	9,400

In Ireland although the cost of milk production is generally higher with autumn-calving herds, the quality of the milk produced from the silage-based diets can also be higher compared with milk from spring-calving herds in a pasture-based system. In an evaluation of autumn and spring-calving herds O'Brien *et al*. (1999) reported superior processing characteristics (higher fat, total protein and casein concentrations) from the former herds due to a higher plane of nutrition, with a minimum of 70% milk from autumn calvers being added to the milk from spring calvers to ensure the milk was suitable for processing into cheese.

Many autumn calvers will still be producing high yields when turnout to grazed pastures occur, particularly late calvers and those with delayed conception. These cows have the potential to increase total milk output by producing a 'second peak yield'. Therefore, they will respond to good management and many of the management options and implications of grazing higher-yielding cows highlighted in the section on 'Spring calving pattern' are relevant to these dairy herds. Where there is a wide variation between cows in yield there the option of buffer feeding the higher yielding cows (including feeding a TMR as part of the diet) separately may be beneficial in not only maintaining yields but also in reducing the risk of potential problems.

The predicted stocking rates on farms with an autumn-calving pattern are generally higher than for herds calving in the spring at 2.3 v 2.0 cows/ha (ABC, 2004). In intensive systems the stocking rate may be a factor to be considered in areas where there is a limit on the quantity of nitrogen that can be applied to the land or when farms have water courses (rivers, streams etc) running through the farm.

6.3. Summer calving pattern

For many farmers a summer-calving pattern (June-August) is focused on producing milk in the period when the maximum benefit can be obtained from seasonality payments. Summer calved herds often require buffer feeding to be introduced as part of the normal management routine to ensure the level of milk production is maintained from the herd, including milk persistency during lactation. Cows calving in the summer period have the potential to produce a large proportion of their total annual output during the July-November period when the seasonality payments made by some milk buyers encourage farmers to produce milk in this period. Seasonality price adjustments (Nix, 2004) of +1.33 (July), +1.70 (Aug), +0.98 (Sept), + 0.78 (Oct) & +0.63 (Nov) can markedly increase total milk income. However, Holt-Martyn (2003B) reported that since deregulation the option of summer-calving cows was becoming less popular for a number of reasons, with producers moving to an easier autumn/early winter pattern. These include a change that has been introduced by some milk buyers from seasonality payments to the requirement to produce a more even production of milk throughout the year. Other reasons for the reduced interest in summer calving include dietary concerns as higher-yielding cows may be better suited to TMR diets and also a worsening fertility status within some herds. Factors, including the quality and availability of herbage during the summer/autumn period and the need for suitable conserved forages can also have a negative effect on the attractions of calving cows during the summer. Feed costs, including high-quality buffer feeds to balance the decline in herbage quality (Poole, 1988; Browne *et al*., 1993) are likely to lead to higher production costs than for a spring-calving herd. Phillips (2001A) also emphasized the potential extra costs involved with summer calving and stated that compared with cows calving in other season, summer-calving cows required more concentrates due to both the declining quality of the late summer/early autumn grass, during a period of potential high milk production, and the need to feed concentrates during the autumn/winter period to balance the silage in the diet.

However, in two reports by Poole (1988) and Browne *et al*. (1993) the results from both experimental trials and the experience on commercial farms moving to a summer-calving season showed a number of benefits as well as disadvantages for herds calving in the summer. On commercial farms summer calving was favoured because of less hassle and stress compared with other calving seasons and the peak workload occurring during the period of good weather. Cows were able to calve outside in clean conditions, reducing the risk of health problems. Some farms favoured summer calving as this fitted in with holiday times and other activities – however, this assumes both a tight and regular annual calving pattern. In a summer-calving herd the cows can calve outside in clean conditions that reduce the risk of any infections spreading from cow to cow. Cases of environmental and summer mastitis are likely to be lower compared with cows calving on other seasons (Poole, 1988).

Disadvantages reported by Poole (1988) and Browne *et al*. (1993) include the decline in the availability and quality of grazed herbage during the summer and early autumn periods and between-season variations in the type of growing season that influence how much herbage is available for grazing and the quantity of buffer feed (e.g. silage) that is required to provide adequate diets. The establishment of grass/clover swards, whose quality during the summer will be higher than grass-only swards, can improve herbage intake and milk output and reduce the quantity of buffer feeds that are required. In addition to the changes in grass growth patterns, the rejection areas in the grazing fields will increase as the grazing season progresses, leading to a lower efficiency of milk production from grazing. The system is reliant on high grazing management standards during the spring when grass growth and quality peak, but the cows are in the non-lactating period. There is the need to graze these cows tightly to avoid excessive weight gain and the opportunity to take early cuts (weather permitting) of both first and second cuts of silage. Amies (1981) stated that a major disadvantage of summer-calving herd was that the cows did not benefit, unlike those calving in the spring, from the advantages of high quantities of quality spring herbage during peak lactation. These results suggest that calving cows in the summer is only likely to be attractive to those well managed high-yielding herds feeding TMR all the year, with the higher costs of production balanced by efficient feed conversion, good fertility and a high milk income. For other dairy farmers there may be little attraction in housing and feeding these cows on silage diets due to the higher production costs and failure to benefit from a ‘second peak’ of production in the following spring. Summer-calving cows have also been found to have lower lactation yields than those calving in spring, autumn or winter (Brouek *et al*. (2004) and in a study of the reproductive performance of British Friesian cows, Darwash *et al.* (1997) reported that the number of days from calving to conception was higher in summer-calving cows compared with those calving in either the spring or autumn periods.

6.4. Winter calving pattern

With the exception of the USA, where there are herds calving specifically in the winter period (December-February), there is little information on the performance of winter-calved herds. In the UK cows calving in the winter period are generally defined as either ‘late autumn’ or ‘early spring’ calvers. Any cow calving during the winter will produce a ‘second’ peak yield when changing from silage-based to grazed herbage diets.

6.5. Year-round calving pattern

Two major advantages for producers with a year-round calving pattern are the ability to provide a relative stable supply of milk throughout the year and also the more consistent month to month milk fat and protein values. With the exception of the period when the diets are changed from silage-based to grazed diets and vice versa, there is the potential to sustain milk quality at the levels required by the milk buyer. For those farms that are processing the milk on site both these factors are important unless an additional supply of milk is available from a nearby farm.

An important factor to consider when a herd calves year-round is how the herd will be managed during grazing in the summer and being fed silage-based diets in the winter. As stated elsewhere in the review, dividing cows into sub-groups has both benefits and disadvantages. In herds where cows calve throughout the year the subject of groups of a single herd is a more critical factor that needs to be considered. Therefore, unless the management policy is to flat rate feed the concentrates the question to be answered is: Can different groups within the dairy herd be formed within the existing winter housing buildings or grazing system? While in-parlour concentrate feeding will allow some flexibility in the quantity of concentrates that can be fed to the individual cow, when high quantities of concentrates are fed there will be a need to feed some concentrates out of the parlour either on top of the silage-based diet or within a total mixed ration. On farms feeding all the concentrates out of the parlour the dairy herd may need to be divided into separate groups (e.g. dry cows, lower yielders, higher yielders) irrespective of whether the cows are fed concentrates separate from the silage or as part of a total mixed ration. If concentrates are fed during the grazing season according to individual milk yields then either the cows will have to be divided into low or high yielding groups with the potential to implement a Leader/Follower grazing system, or different levels of concentrates will need to be fed either in the parlour or by dividing the cows post-milking into separate groups.

When a herd calves throughout the year the question needs to be asked as to whether this was a result of a deliberate management decision or the failure to achieve a good reproductive performance within the herd due to lower standards of stockmanship, poor quality diets (low energy, excessive protein, mineral deficiency) or the presence in the herd of a health problem. If the herd calves all the year round due to management problems then the calving index will be increased, leading to a reduction in both the annual total milk production and milk yield/ha and also the total income from the enterprise. Unless the problems are addressed the culling rates will be increased, leading to an increase in the number of replacements being reared and a lower than optimum productive to non productive animal ratio on the farm.

6.6. Block calving cows within different calving patterns

Deciding to move to a block-calving system where all cows calve within a tight pre-defined period of a few weeks has a number of advantages. The discipline required to operate the system can simplify the management of the herd with calving, heat detection, inseminations and drying off all occurring within tight time periods in the year (Amies, 1981). Other jobs including dehorning and passport applications can also be completed within a short period. While some dairy farmers welcome a more disciplined approach to herd management and rise to the challenge of peak labour inputs, others prefer the variety of monthly tasks that is associated with, for example, a year-round calving pattern and the avoidance of 'peak pressure periods' that can occur with a tight calving pattern. Amies (1981) suggested that in itself block calving would not lead to improved performance but may on some farms create conditions that are conducive to the achievement of better results.

Traditionally in Ireland and New Zealand a block-calving system for spring-calving cows has been essential as grass is the cheapest feed and most of the milk has been sold at a low price for manufacturing and the price structure did not encourage winter production (Amies, 1981).

In the UK Phillips (2001D) suggested that block calving was not the optimum system for high-yielding cows as they would still be producing >10 litres/day when drying off occurred.

ADAS (1985) stated that changing to a block-calving system could be achieved in three ways:

1. By changing the calving date of homebred heifers
2. By manipulating the calving date of cows already in the herd
3. By purchasing additional animals

6.6.1. Key targets in a block-calving system

Block calving offers the challenge of providing high quality diets during the early lactation period to ensure conception rates are high, with cows conceiving by day 80 post calving. Gibson (2000) suggested a target 90% submission rate for the herd with 100% of the herd submitted for mating at least within seven weeks and 80% of the cows conceiving within six weeks. For a spring-calving herd Mee *et al*. (1999) suggested that to achieve a tight calving period 90% of the herd should calve within an 8-week period. Targets suggested by Ramsbottom (2003) were for 75% of the herd to calve within six weeks (95% of heifers) and a total calving period no longer than thirteen weeks. This requires excellent heat detection and a low number of serves/pregnancy to achieve the target of the herd calving within a tight pre-defined time period of 10-12 weeks (Amies, 1981). A strict cut-off date is required for the last service date if the block-calving pattern is to be maintained. Maintaining a tight calving pattern can increase the culling rate, particularly if body condition scores are below optimum during the critical period when inseminations are being carried out. One of the most difficult challenges is to achieve conception in the cows calving towards the end of the target period as these animals will require serving soon after calving. Better conception rates are achieved if service is delayed until 60 days post-calving (Amies, 1981) but this is not an option for these later calving cows.

Maintaining the system within the target period will inevitably lead to difficult decisions – on some farms it will involve culling non-pregnant cows that are not only high-yielding but also have a good health status, excellent conformation and desirable temperament. Where little or no concentrates or buffer forage is fed block calving can lead to a problem in some herds (e.g. spring/autumn calvers on a low-cost system) due to the problem of low milk protein values during the early post-calving period. Although Ramsbottom (2003) stated that a tight calving pattern improved profitability of a pasture-based system when he evaluated the results from 66 spring-calving herds in Ireland he found that milk protein values in a number of herds were below 3.0% in the post-calving period prior to turnout, with proteins improving by 0.2% when cows changed from silage to herbage-based diets. Unlike herds with a more extended calving pattern, the block calving herd cannot balance any low protein milk from fresh calvers with the higher protein milk from cows in mid/late lactation.

In a block-calving herd the calving date of heifers entering the herd is critical with the objective of ensuring heifers calve at the start of the block calving period. On some dairy farms syncronisation provides an opportunity to ensure the required calving date is achieved with the majority of the heifers.

6.6.2. Is block-calving viable in a high-yielding herd ?

Selecting a pre-defined annual target for the dairy herd is easy to choose when planning the future management of the herd but in practice may be hard to achieve, particularly in higher-yielding herds where the quality of the diets and standards of management (e.g. heat detection) need to be high. This is clearly shown by the increase to 414 days in the average calving index of UK dairy herds (Esslemont, 2002B). For many herds this increase will be a result of an increasing number of cows moving away from the target calving period (i.e. block calving) to year round calving rather than an acceptance that a higher 'failure to conceive' culling rate is part of the management strategy to maintain a tight calving pattern. Any delay in the date of conception not only increases the calving interval but also has financial implications. Esslemont (2002A) calculated that the average UK dairy herd achieving 7,000 litres/cow was losing 4 ppl through wastage from low reproductive performance, culling for other reasons and ill health within the herd – equivalent to £30,000 in a 100 cow herd. While some of these losses are inevitable (e.g. some cows in a herd will become lame or get clinical mastitis) other losses can be lowered by more efficient management. Unless the management policy of a herd is to allow cows to breed year-round with future budgeting based on this policy, then the implications of irregular calving need to be considered. Using the indices for fertility (FERTEX) and health problems (HEALEX), Esslemont (2002A) calculated the targets for maintaining good reproductive and health performance within a herd and also measured the financial effects of increasing wastage within the herd.

Table 14: Targets for the dairy herd and the implications of deviations from the target (Ref: Esslemont, 2002A).

Performance:	Target	Adequate	Slight problem	Moderate problem	Severe problem	UK average
Crucial factors:						
Percent served of calved (%)	94+	90-93	87-89	84-86	<83	83
Calving to first service (days)	55-65	65-69	70-74	75-82	>83	85
1st service 24-day submission rate (%)	69+	59-68	48-58	33-47	<32	48
Returns service heat detection rate (%)	68+	59-68	53-59	40-52	<39	48
1st service pregnancy rate (%)	58+	52-57	47-51	42-46	<41	40
All services pregnancy rate (%)	58+	52-57	47-51	42-46	<41	40
Outcomes:						
% of served cows conceiving	96+	92-95	89-91	85-88	<84	84
% of calved cows conceiving	88+	82-87	79-81	74-78	<73	73
Average days from calving to conception	70-86	87-93	94-101	102-113	>113	128
Calving interval (days)	350-369	370-376	377-382	383-385	>395	408
Days open	86-109	110-120	121-133	134-154	>154	160
Failure to conceive culling rate (%)	4-7	8-10	11-14	15-16	>16	17
All other culling rate (%)	</=10	11-12	13-14	15-16	>16	16
Total culling rate (%)	12-16	17-20	21-23	24-30	>31	33
FERTEX score (£/100 cows)	</= 0	0-3,500	3,500-7,200	7,200-12,200	15,400	17,475

As Table 14 shows any deviations from these targets have implications when the total costs of milk production are calculated. These results illustrate clearly that poor reproductive performance, even if other health problems and culling rates are similar to the targets, will have a marked effect on the financial viability of a dairy system, irrespective of the calving pattern of the herd and whether the calving pattern resulted from a management decision to set a defined target calving period or was a result of natural slippage in the conception date during the year.

Esslemont (2002B) stated that on many dairy farms with infertility problems a number of practices had been introduced to keep culling rates down. These included abandoning calving patterns and keeping sick (lameness, mastitis) but fertile cows, leading to high-yielding cows calving in an inappropriate month. Rather than being turned out to grazing pastures these cows were being housed all year, resulting in an increased incidence of lameness and mastitis within the herd.

As shown by Esslemont (2003) in the following table an increase in the number of days from calving to conception has greater financial implications for the higher-yielding cow producing 10,000 litres compared to the cow yielding 6,000 litres.

Table 15: The financial effect of delayed conception (Esslemont, 2003).

	Value of milk loss @ 18.5 ppl	Net cost £/day of delay after quota	Cumulative cost (£)
1. 6,000 litres/cow/year			
85-100	1.84	1.73	
101-115	2.54	2.30	60
116-145	3.19	2.86	146
146-175	3.93	3.55	253
2. 10,000 litres/cow/year			
85-115	2.13	1.68	
116-145	3.68	2.47	125
146-175	5.03	3.20	220
176-205	6.20	3.87	336
206-235	6.56	4.08	459

If the decision is to move to a block-calving pattern, then the option of two block periods each year, rather than one, may have attractions and allow late-calving cows to ‘roll over’ from one calving season to the next. This would provide a more stable milk income throughout the year and offer the opportunity to run a higher input autumn-calving group separately from a low cost spring-calving group. However, both the financial implications and the complications of running two contrasting groups (e.g managing two separate grazing herds) would not be attractive or feasible on smaller dairy farms. For example an efficient manager of a low cost grass-based system may not wish to manage a higher input herd and find achieving the required standards rather challenging. Unless strict discipline was maintained the two-peak periods could easily change over a period of time to a year-round calving pattern which would have both benefits and disadvantages compared with the two-block peak system.

De Vries (2004) developed a computer model to evaluate whether cows calving out of the target calving season should be replaced by purchasing in-calf heifers as replacements. The results from the model showed that while immediate replacement of culled animals was financially advantageous when analysed on a whole-year basis, economic benefits may be gained by delaying the replacing of culled cows at specific times during the year when milk seasonality payments and the cost of production per unit of milk were taken into account.

6.6.3. Replacements for a block-calving herd

It is not only a challenge to achieve conception in the mature cows, first lactation heifers calving at 2-years of age need to not only produce milk and conceive but also divert dietary nutrients towards growth. If possible these animals would benefit from being kept in a separate group and away from the generally more dominant and physically aggressive older cows. The system allows calves of a similar age to be reared together with the aim of achieving 2-year old calving within a short time period. In herds with two block-calving periods during the year there is the flexibility to delay the insemination/natural service of heifers not achieving the target live weight at first service, however, any long delay will increase the costs of replacement animals entering the herd.

6.6.4. Block calving can lead to a period during the year when all cows are dry

The combination of maintaining a block-calving pattern with cows calving within a limited time period combined with a low calving index offers the chance to have a small period each year when no cows are in milk. This period can be used to make any changes or major repairs that are required to the milking parlour and ancillary equipment. With changes in the social patterns among younger dairy farmers this is useful in allowing the chance for farmers with limited available labour to take time off for holidays, exchange visits etc without being concerned about how the farm will function while they are away.

6.7 12 versus 18-month calving pattern

The suitability of aiming for a 365-day calving interval has been questioned by some researchers due to the high milk yields, increase in metabolic disorders and declining reproductive performance of dairy herds and the high culling for infertility in some herds. The option of calving cows every 15 or 18 months rather than aiming for the more accepted annual calving has already been discussed and limited evaluations carried out by some researchers in Europe (Knight, 1997; Bertilsson *et al*., 1997; Knight, 2004). The specific problems associated with drying cows off at yields of >20 litres/day have also been highlighted (Knight, 1997) and Knight (2004) suggested that high-yielding cows should not be expected to calve every 365 days. Calving time is the most crucial time for the dairy cow with

60% of veterinary costs incurred during this period and Knight (2004) suggested that moving from a target 12 to 18-month calving interval would reduce veterinary costs. Lactation length can be increased by two methods, either by moving the whole curve upwards (enhanced yield), or by changing the shape of the curve to sustain milk persistency and reduce the rate of decline in yield after peak lactation (Knight, 1997).To ensure milk persistency was maintained throughout the longer lactation and as milk yield is regulated by a secretion-inhibiting chemical, Knight (2004) suggested cows were milked 3-times/day to achieve higher yields, however, the preliminary results from a study in Sweden (Bertilisson *et al*. (1997) showed no benefits in milk persistency when cows were milked 3 rather than 2-times/day. In a comparison of the 12 versus 15-month calving intervals in one herd Bertilsson *et al*. (1997) recorded better conception rates (42 v 50%) and pregnancy rates (81 v 93%) when the calving interval was extended. However, in another herd where 12 versus 18-month calving intervals were compared, similar conception rates (52%) and pregnancy rates (100%) were recorded. In the 12 versus 18-month comparative study there were only small differences in the energy-corrected milk yield up to week 24 post-calving. From week 32 the cows in the 12-month group showed a faster decline in milk yield and the authors suggested this was due to the increasing stage of pregnancy. The milk yield of cows in the 18-month group decreased after the sixth month of lactation.

As shown elsewhere in the review the financial cost analysis of the effect of extended calving intervals often show increased costs due to lower annual milk yields, fewer calves, more services, extra veterinary costs and the failure to calve cows in the most profitable calving months. Also to sustain milk persistency extra feed costs would have to be included when the viability of extended lactations is evaluated. The management implications, extra costs of 3-times/day milking and annual changes in the between-month milk output in relation to milk contracts would also need to be examined closely before a policy of extended lactations was even considered, let alone implemented.

7. THE FINANCIAL IMPLICATIONS OF DIFFERENT CALVING PATTERNS

While the next stage of the project will produce sensitivity tables and a flow chart comparing the financial implications of different calving patterns, this section of the review briefly reviews some of the published data on the relationship between calving pattern and the financial performance of a dairy herd and may provide useful information for developing the flow chart and sensitivity tables.

f the calving pattern of a dairy herd is to be changed then the implications in relation to financial cost need to be calculated. ADAS (1987) stated that the time of calving should be planned to take advantage of the highest milk price. Changing the calving pattern may have a marked influence on the financial income of the enterprise during the year, ranging from relatively small differences in monthly income from year-round calving to large differences in a block-calving herd. Seasonality payments for an autumn-calving herd with a tight calving pattern will potentially lead to major fluctuations in the size of the monthly milk payments while dual-pricing (core volume + marginal volume) can benefit the dairy farmer as the system recognizes that the cost of producing milk in the autumn is higher than in the spring. DANI (1998) calculated the gross margins for cows calving in every month of the year. As shown in the table below the requirement for concentrates to balance the diets varies each month leading to differences in the gross margin/litre. The table also shows the weighted price differential that is required to ensure the highest gross margin (March calving cow) is achieved, irrespective of the calving month. It should be noted that these calculations do not include any extra costs associated with calving in specific seasons, including higher conserved forage costs, differences in overheads and other costs.

Table 16: The influence of the calving season on concentrate inputs, gross margin/litre and the required difference in weighted milk price that is required to ensure gross margins per cow reach the highest figure (e.g. March calver). (Adapted from Mulholland & Hutchinson, 1998).

Calving month	Concentrates fed (kg/cow)	Gross margin/litre @ 20 p/litre, £140/t concentrates	Weighted average milk price required to achieve the highest gross margin (i.e. March calving)
April	500	16.7	0.2
May	820	16.0	0.9
June	1,020	15.6	1.3
July	1,250	14.7	2.2
August	1,220	14.8	1.9
September	1,180	14.9	2.0
October	980	15.2	1.7
November	820	15.6	1.3
December	720	15.9	1.0
January	600	16.3	0.6
February	480	16.6	0.3
March	400	16.9	0

Analysis by the ADAS Dairy Group (Powell, 2004) showed that in 2004 there was a range in milk price of up to 2 ppl, depending on the milk buyer and the profile of the milk supplied. The milk profile was produced from the MCi milk forecast module. They calculated the affect on milk income from herds with five different calving patterns (year-round, spring, summer, autumn and winter) and the variable price paid by six major milk buyers. For ease of tabulation each herd was based on 120 cows selling 840,000 litres/annum with daily collection. Milk quality was based on 4.0% fat, 3.3% protein, bactoscan 28,000/ml and 170,000 somatic cells/ml. The number of cows calving in each month for the five different calving patterns is shown in the following table.

Table 17. The estimated number of cows calving in each month for the five different calving patterns (Ref: Powell, 2004)

Month:	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Total
Year-round	10	10	10	10	10	10	10	10	10	10	10	10	120
Spring	40										40	40	120
Summer		40	40	40									120
Autumn					40	40	40						120
Winter								40	40	40			120

The two key periods of milk production are in the April-June period (UK peak production) and September-November (UK trough in production). The following table shows the percentage of milk produced from the five different calving patterns during the two peak periods.

Table 18: The production of milk from the five calving patters during the two key periods of production (Ref: Powell, 2004)

% of total annual production	April-June period	September-November period
Year-round	24	24
Spring	35	25
Summer	12	35
Autumn	20	29
Winter	31	11

The table below shows the price for each calving pattern compared with the lowest calving period. For all except Buyer 6, the lowest milk price would be paid for the ‘winter’ calving pattern (i.e. calving from November-January). For Buyer 6 the lowest milk price would be paid for the herds calving in the spring, almost identical to the ‘winter’ calving pattern milk price. This is explained by the low proportion of milk (11%) produced in the September-November period and the high proportion (31%) produced in the April-June period. The table shows that most producers would achieve a higher milk price by adopting a calving pattern which is based more on summer or autumn calving. However, further price changes by one buyer led to a level profile attracting the highest price. In practice this could be achieved by either a year-round calving pattern or calving in two blocks that are six months apart.

Table 19: The range in milk price paid for the different calving patterns by six commercial milk buyers (Powell, 2004).

Buyer	Year-round	Spring	Summer	Autumn	Winter	Range
1	1.6	0.2	0.9	0.7	0	1.6
2	0.3	0.1	0.6	0.2	0	0.6
3	0.3	0.1	0.7	0.3	0	0.7
4	0.9	0.2	2.0	1.5	0	2.0
5	1.3	0.9	1.4	1.6	0	1.6
6	0.9	0	1.8	1.8	0.1	1.8
Range	1.3	0.8	1.4	1.6	0.1	

A key factor in any calculations is the fact that peak production is not recorded at calving but at a later date (e.g. 5-6 weeks post-calving). The analysis by the ADAS Dairy Group stated that the new seasonality schedules primarily reward production in the September-November period, the UK trough. Therefore, a herd with a late summer calving pattern will peak in autumn. The Group also advised that no producer can ignore the implications of price differences due to the individual calving pattern and milk production profile, as new contracts may have a range of £15,000 in total annual milk income. They concluded that the new seasonality and profile payments would particularly affect producers with either a tight winter or spring-calving pattern. Under CAP reform, producers with either a winter or spring-calving pattern will increasingly be affected by lower market returns as any surplus from the peak production months of April-June goes into intervention products which will produce a farm gate price below 14 ppl by 2008.

When comparing the costs of milk production between herds that have the same calving pattern but are located in different countries the influence of differences in climatic conditions need to be considered in the evaluation. Climate has both a direct effect on performance (e.g. changes in intake, yield and fertility) and costs of production (investment in housing). For example, autumn-calving cows in many parts of the USA require a higher investment in buildings with high standards of insulation required to enclose the cattle sheds during the winter and avoid the problems associated with low temperatures (Scanlon, 2003). Conversely in the summer these dairy herds require the installation of fans and sprinklers in the summer to avoid the problems associated with high temperatures and humidity.

8. FURTHER REFERENCE SOURCES WITH PRACTICAL ADVICE FOR FARMERS

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