

15

Nutrition and fertility

This chapter:

Explains the effect of both nutritional and non-nutritional factors on the reproductive performance of the dairy herd.

The main points in this chapter:

- how to calculate submission rate and conception rate and use them to describe a herd's reproductive performance
- nutrition is only one of many factors affecting reproduction
- low energy intakes in early lactation can delay the first detected heat and depress the rates of submission and conception
- cows will inevitably be in negative energy balance in early lactation, but good reproductive performance depends on cows:
 - calving in good condition (score 4.5–5.5)
 - reducing the drop in appetite after calving
 - reducing the rate of body condition loss during early lactation, to less than one condition score.

So far in this manual, feeding strategies have focused primarily on achieving optimum milk production. However, to achieve higher production per cow through better management, better genetics and better nutrition, other aspects of cow performance must also be considered. One of the most important of these is fertility or reproductive performance.

Improved reproductive performance provides many benefits to farmers, such as:

- higher average milk yields each day. Cows with poor reproductive performance will spend more of their time in late lactation, when daily milk yields are lower
- fewer cows that have become excessively fat because they have failed to conceive

- less compulsory culling of cows failing to become pregnant
- reduced insemination and semen costs
- heifers calving at a younger age
- increased number of calves produced each year, thus providing more animals for sale or as replacements for the milking herd
- more efficient feed utilisation as a result of the above benefits
- more profits, less work and less worry.

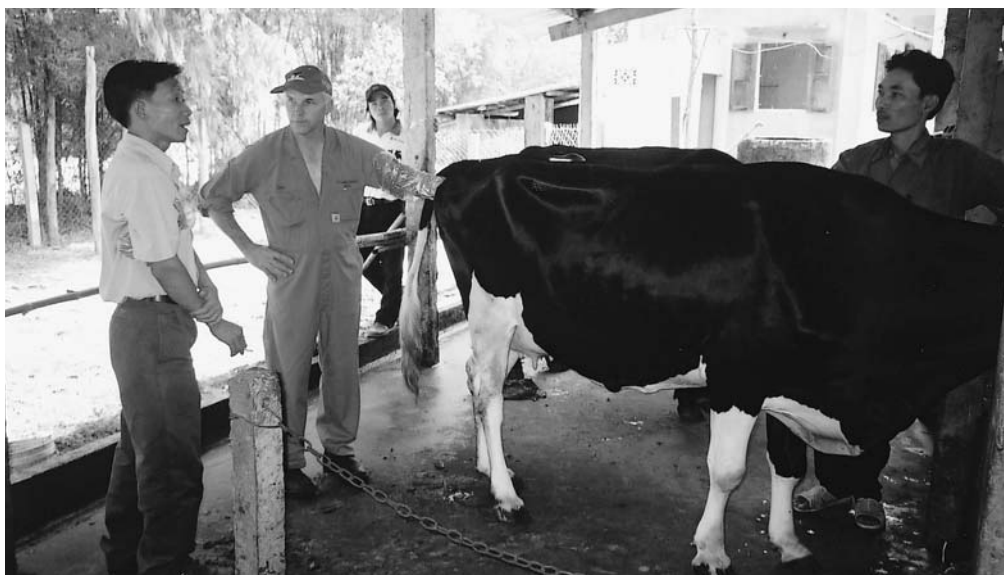
This chapter discusses some of the ways that nutrition affects fertility. Before discussing the effects of nutrition on reproductive performance, reproductive performance needs to be quantified.

15.1 Measures of reproductive performance

For year-round calving herds, there are two useful measures of reproductive performance. These are:

- 100-day in-calf rate. This calculates the percentage of the cows in the herd that become pregnant by 100 days after calving. It also describes how many cows will calve within about 13 months of their previous calving.
- 200-day not-in-calf rate. This calculates the percentage of cows not pregnant by 200 days after calving. Farmers want as many cows as possible to calve within 15 to 16 months after their previous calving.

To calculate these two measures of reproductive performance, one must know accurately when cows become pregnant. It is best to base this on pregnancy testing when cows are between 5 and 15 weeks pregnant. To achieve this, a herd pregnancy testing routine is necessary. Cows not returning to service should be examined on the next



Reproductive management requires routine pregnancy diagnoses as well as good record keeping (Binh Duong province, Vietnam).

pregnancy testing day until they are confirmed pregnant. Pregnancy testing cows every one to two months allows most accurate monitoring.

Two other measures are frequently used to describe reproductive performance. These are average calving to conception interval (or days open) and intercalving interval. These measures are not ideal because there are three major problems with their use:

- They are only averages and do not indicate how many cows actually had long calving to conception intervals. Such problem cows require attention.
- They do not take into account cows that do not become pregnant at all. Obviously these non-pregnant cows are also problem cows.
- These measures can include cows that are routinely inseminated many months after calving, such as high producing cows, which are normally culled as non-fertile.

Submission rates

The submission rate is the percentage of the herd which received at least one insemination within a specified number of days after calving.

To achieve a high 100-day in-calf rate, a high percentage of cows in the herd must be submitted to insemination without undue delay after calving. The 80-day submission rate is the percentage of cows that receive at least one insemination by 80 days after calving.

Conception rates

Conception rates are the numbers of services resulting in pregnancy divided by the total number of services.

This describes the percentage of inseminations that are successful and result in pregnancy. This has always been considered an important measure of reproduction but it does not fully describe overall herd performance. Herds can have high conception rates but poor 100-day in-calf and high 200 day not in-calf rates because of very low 80 day submission rates. Sometimes the first insemination conception rate is calculated by including only the first services after calving in the analyses.

Conception rate is only one aspect of reproduction because herd performance is also dramatically affected by:

- time from calving to first insemination
- percentage of returns to service that are detected
- high levels of reproductive performance can be achieved with only moderate conception rates when submission rates are high and a high percentage of returns to service is detected.

Data from Australian dairy farm surveys can provide a guide to actual and achievable reproductive performance in year-round calving herds. These are presented in Table 15.1.

Table 15.1 Achievable measures of reproductive performance in year-round calving herds

(Source: Morton *et al.* 2003)

Measures of reproductive performance	Seek help	Top farmers achieve
100 day in-calf rate	<45%	58%
200 day not-in-calf rate	>19%	13%
80-day submission rate	<61%	73%
Conception rate	<43%	51%

High submission rates are essential for high 100-day in-calf rates.

This large-scale Australian study identified six factors which have large influences on herd reproductive performance. Three are non-nutritional and three are nutritional. They are:

- The length of the voluntary waiting period (ie the number of days delay after calving before farmers begin inseminations). This is 50 to 55 days in the herds with the best fertility.
- Heat detection. Farmers can make two types of mistakes: they can diagnose heat in cows not on heat (called a false positive) or miss a heat identification (undetected heat). Missed heats are more common. The higher the heat detection rate, the higher the submission rate. Farmers with over 80% heat detection rates had 73% 80-day submission rates.
- Artificial insemination (AI) practices. There are many skills in AI, but discussion of these is outside the scope of this manual. Good first insemination rates were 45 to 48%.
- Body condition. Cows calving at condition scores of 4.5 to 5.5 (where 1 = emaciated and 8 = extremely fat, see Chapter 18) had higher 100-day in-calf rates (54%) than those calving at less than 4.5 (41%). Cows calving in very high score (6.0 or more) may lose condition more rapidly after calving and can suffer reduced fertility.
- Feed intake. Better fed cows have higher fertility. Better feeding can improve 100 day in-calf rate from 41% to 57% and reduce 200 day not in-calf rate from 15% to 9%.
- Heifer live weight. The occurrence of the first oestrus in yearlings depends on live weight. Therefore, better feeding practices in early life will lead to younger age at first calving in virgin heifers. These heavier animals will also cycle earlier after calving.

15.2 Non-nutritional factors that affect reproductive performance

Reproductive performance is affected by many factors. Nutrition is only one possible cause of poor reproductive performance. In some herds, nutrition is not the most important cause of poor performance. Some of the other causes can be divided into those that affect submission rate and those that affect conception rate.

The many factors affecting submission and conception rates in tropical small holder herds are listed in Table 15.2, categorised into:

- difficult to influence (generally outside farmers control)
- possible to influence (require some management skills and/or capital)
- easy to influence (require little management skill and/or capital).

It is easier to improve submission rates than conception rates. For example, submission rate may be increased from 40% to 80% with careful management, whereas conception rates may only improve from 30% to 45%. Many of those factors influencing submission but not conception rates are behavioural, such as decreasing the length of the voluntary waiting period and making more effort to improve heat detection.

Table 15.2. Factors affecting submission and conception rates with artificial insemination (or *natural mating*) in tropical small holder herds

(Source; Moran and Tranter 2004)

Ease of influencing	Submission rate (Cows being submitted for insemination or mating)	Conception rate (Services per conception)
Difficult Outside farmer control	Mineral deficiencies (defining what minerals)	Semen quality Infectious diseases (requiring government support) Mineral deficiencies (defining what minerals)
Possible Requires some management skills and/or capital	Heat stress Genotype × environment interactions Feeding to cows potential Genetic tendencies for lactation anoestrus Support of infrastructure (eg facilities)	Semen handling AI technique Heat stress
Easy Requires little management skill and/or capital	Deferral of insemination or voluntary waiting period Heat detection Age Heifer size (and age) at first calving <i>Bull performance</i> <i>Bull:cow ratio</i> Body condition at calving Body condition loss after calving Induced calvings Post-calving nutrition (energy, protein, fibre) Health problems Uterine infections Lameness Retained foetal membranes Milk fever Cystic ovaries	Timing of insemination <i>Bull fertility</i> Body condition at calving Body condition loss after calving Post-calving nutrition (energy, protein, fibre) Diseases affecting fertility Uterine infections Other diseases

Heat detection in tropical herds using artificial insemination only

Observations of oestrus are more difficult in the tropics due to anoestrus resulting from poor nutrition and/or intensive suckling. Furthermore, the oestrus period is shorter (10 to 12 hr), signs are less pronounced or mainly shown at night (in buffaloes or local cattle) when farmers are less keen on, or active in, heat detection.

For practical purposes, most small holders use Artificial Insemination (AI) rather than natural mating. This introduces another set of factors limiting herd fertility. Cows tied up in a stall can hardly express the most easily recognisable signs of oestrus like mounting and being mounted.

Cows show signs of heat when they:

- are 18 to 24 d after their last heat (if they are still non pregnant)
- stand to be mounted
- attempt to mount other cows
- are restless and bellow
- have reduced feed intake
- have poor milk let down

- have stringy mucus exuding from their vulva
- have a red and swelling vulva (locally known in Vietnam as 'redneck').

The average duration of heat is about 14 h in normal weather. Heats can be as short as 2 h and as long as 28 h. Observations twice per day are then essential to catch short heats. Observations in the cool of early morning are more likely to detect heat than those in the hotter parts of the day.

The best conception rates occur following insemination 4 to 12 h after the first signs of heat are observed. However, the problem is knowing at what stage of oestrus the particular heat was first detected.

Heat detection can be improved with:

- routine night observations
- interpreting cow behaviour
- checking records for days since previous heat (for closer observation)
- using heat detection aids in larger herds, although tail paint is a cheap effective aid for most farmers
- using oestrus synchronisation as a management aid.

Small holder farmers who continually tether their cows are disadvantaged because cows cannot move around to show the easiest to interpret behavioural signs of heat. Having a small yard in which to let the cows out, say before milking, will aid detection. Using heat aids, such as tail paint or heat mount detectors, can improve detection rates. Vasectomised bulls or hormone treated steers running with the mating herd are also useful in larger herds. Heat synchronisation can offer efficient use of labour as the work of heat detection and artificial insemination is shortened into planned, intensive periods.

Each month farmers need to identify cows which have calved more than 80 days before, but have not been detected on heat, and examine them. This is important if more than 60% of the herd are in this category. Some of these cows may have had an undetected heat, whereas others may not have been on heat and can be treated as non-cycling cows. If most of these cows are in low body condition, their feeding management should be improved. Others may be suffering disorders such as cystic ovaries, infected uterus, and lameness, thus requiring veterinary attention.

Other important factors should be taken into account, such as:

- body condition, too fat or too thin
- rapid loss in body condition
- small heifer size
- diagnosed health problems, such as cystic ovaries, uterine infections, lameness
- heat stress, as apparent from observed high respiration rates and/or high temperature humidity index (see Chapter 19 and Appendix 1).

Assuming heat can be detected early, the message must be passed on to and be acted on by the AI technician. Most dairy cooperatives have a simple and effective system of communication between farmers and AI technicians. Assuming the technician can reach the cow in good time for insemination, the factors listed above are relevant.

15.3 Nutritional factors that affect reproductive performance

15.3.1 Energy intakes and balance

Energy intake affects milk production, body condition and live weight. Numerous studies have investigated effects of milk production, body condition score and live weight on fertility. Results have varied widely. To date, the effects of energy intake on fertility are not fully understood.

Nevertheless, some effects are clear. The effects of energy intake can be separated into effects on submission rates and effects on conception rates.

Effects of energy intake on submission rate

Table 15.3 presents the effect of extreme undernutrition on the onset of cycling. Cows of various breeds were calved in condition scores ranging from 3 to 6 (see Chapter 18) and were then fed 7, 11 or 15 kg DM/day of pasture for the first 5 weeks of lactation. After that, all groups were allocated the same amount of pasture.

Table 15.3 Effect of condition score at calving and post calving feeding on days from calving to first detected heat

(Source: Grainger et al. 1982)

Pasture fed after calving (kg DM /day)	Days from calving to first detected heat			
	Body condition score at calving			
	3	4	5	6
7	55	49	43	38
11	50	44	39	33
15	46	40	34	28

The first detected heat was markedly delayed among cows in poor condition at calving and cows fed very limited pasture after calving. Because of this delay, submission rates were dramatically reduced in the thin and underfed groups. The study in Table 15.3 assesses the effects of nutrition at the low end of the scale. Large, high-producing Holstein-Friesian cows can consume over 20 kg DM/d. It is likely that the cows in this study would have eaten well over 15 kg DM if they had been allowed. So underfeeding was occurring, even in the best-fed groups in the study.

At the other extreme, cows can be too fat at calving. Cows calving in condition scores above 6 are at greater risk of fatty liver syndrome, with associated reduction in appetite, excessive weight loss and increased likelihood of retained foetal membranes and/or non-cycling. Except for some cows being carried over, grazing cows in Australia are rarely seen in condition scores greater than 6. If low-producing cows are fed better both before and after calving, submission and conception rates are improved, as are milk yields.

Extensive work is now focusing on the effects of nutrition in high-producing cows. Probably the best current explanation of the causes of delayed cycling among high-producing cows comes from North America. Under the systems of management there, it appears that condition loss after calving is more likely to cause delayed cycling than is the level of milk production in early lactation.

The problem, as discussed in Chapter 7, is that milk production peaks before maximum feed intake, even where cows are fed *ad libitum*. Therefore in early lactation, cows' energy requirements exceed their intakes. They are in 'negative energy balance' and so they lose body condition and weight. This is seen as the trough that occurs soon after calving (Figure 15.1). In this study, cows lost condition for the first seven weeks of lactation.

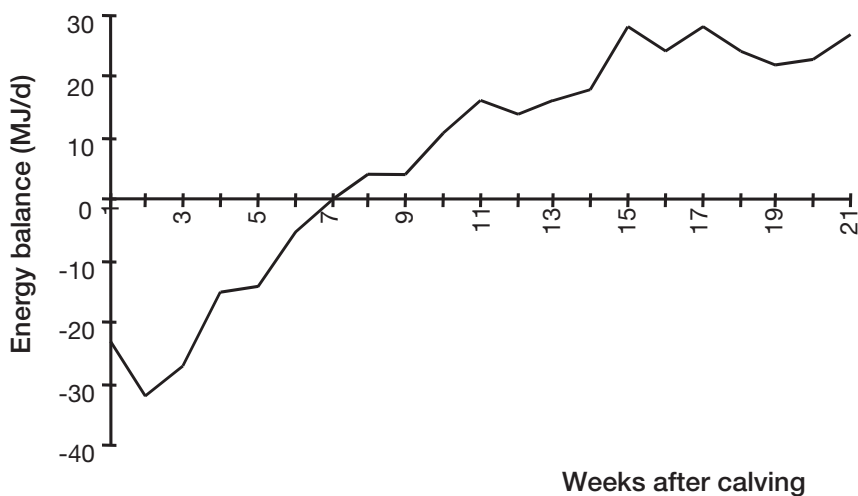


Figure 15.1 Changes in energy balance (in MJ/d) in early and mid-lactation. (Source: Ferguson 1991)

The negative energy balance is worst in the first few weeks after calving, before slow improvement. Intake capacity steadily increases and cows eventually move into positive energy balance. When in positive energy balance, cows began to gain condition.

How does this affect reproductive performance? Some research suggests that cows have their first ovulation about 10 days after the greatest negative energy balance, that is a week or so following their greatest rate of live weight loss. So if the negative energy balance is prolonged, first ovulation will be delayed and submission rates reduced.

Greater negative energy balance (a deeper trough in Figure 15.1) may also cause longer delays to first ovulation. This graph is the average for the group of 40 cows. Clearly some herds will have deeper and more prolonged troughs than others, due to cow type and management.

Importantly, there is also a lot of variation between cows within herds. Higher producing cows will generally have deeper and more prolonged troughs than lower producing cows.

However, the cows with the deepest troughs may not be the highest producers within a herd. Cow appetite can also have large effects. Cows producing a little less but eating a lot less will clearly be at more risk. This effect may be particularly important in forage-based production systems where cows must compete for limited feed.

Effects of energy intake on conception rates

Energy intake and condition score affect onset of cycling after calving. Early onset of cycling clearly increases submission rates. Furthermore, early onset of cycling increases conception rates.

New Zealand research suggests that conception rates are improved in cows, which have had at least one heat before mating (Table 15.4). This is regardless of the length of time between calving and the start of mating.

Table 15.4 Effect of pre-mating heats on first service conception rates

(Source: Macmillan and Clayton 1980)

Number of pre-mating heats	First service conception rate		
	Days from calving to first service		
	40 or more	30–39	Less than 30
0	59	42	32
1	65	49	39
2	67	51	40

Hormonal changes may explain the positive effect of a heat before mating on conception. It appears that high levels of the hormone progesterone in the 12 days before insemination improve conception rates.

The ovary produces progesterone after a cow has ovulated. Cows inseminated on their second ovulation will usually have had much higher progesterone levels for the previous 12 days.

There may also be other explanations for the improvement in conception rates among cows having a heat before mating.

Other effects of energy intake on conception rates

Energy balance may also affect conception rates in other ways. Negative energy balance long before insemination may reduce conception rates. In the ovary, egg development begins around 60 to 100 days before the heat where the egg is released. It may be that adverse conditions around that time can result in a defective egg being produced and released.

If true, this might mean that severe weight loss in early lactation could result in poor quality eggs when cows are inseminated. For late-calving cows, which are mated soon after calving, weight loss in the dry period could have similar effects.

15.3.2 Some implications for management

Management in late lactation

Good herd managers aim to dry off cows in the condition in which they want them to calve. How cows are fed in late lactation and when they are dried off will have huge effects on condition score at drying off and at calving.

Dry cow management

Dry cows must not lose weight. Even if live weight does not seem to be declining, cows may still be losing condition. The increasing weight of the foetus and udder during pregnancy may mask losses of the cow's own body weight.

Cows with higher condition at calving have better fertility. For example, each additional condition score can reduce the time between calving and first feed by five to six days.

Management during the transition period

Decrease in appetite around calving has to be minimised. The cow's rumen needs time to adjust to the new diet. Digestion and intake can be reduced while the rumen is adjusting. This adjustment can start before calving.

In herds where milkers are fed moderate to large quantities of grains, lead feeding (gradual introduction of grain in the diet before calving) helps reduce the impact of dramatic change in diet. Lead feeding may also help retain condition in the last few weeks before calving. Anionic ('acid') salts may enable some forages to be fed to cows due to calve without increasing the risk of milk fever (see Section 13.2.1). Feeding some pasture may help reduce the impact of the dietary changes after calving.

Minimise condition loss after calving

It is crucial to achieve high-energy intakes quickly after calving. The many considerations in feeding cows in early lactation are discussed in other sections of this manual.

15.3.3 Protein intakes

Excess protein

Some diets may lead to the protein content of total diet exceeding cows' requirements. The excess can reduce reproductive performance.

Most of the protein in forages is Rumen Degradable Protein (RDP). Research suggests that diets high in Rumen Degradable Protein depress conception rates. Imbalance between the amounts of fermentable carbohydrate and protein in the diet are the key concern.

Diets with excess protein have effects other than on conception rates. It costs the cow energy to break down the excess protein, energy that could otherwise have been used for milk production and body condition. So, adverse effects of high protein diets on fertility may be due to an energy deficit.

Protein deficiency

The cow's highest requirement for protein is in early lactation. Requirements for both Rumen Degradable Protein and Undegradable Dietary Protein (UDP) increase after calving, especially among high producing cows.

Many of the diets fed throughout South-East (SE) Asia do not provide sufficient protein. This can also reduce reproductive performance.

15.3.4 Intakes of minerals, trace elements and vitamins

Cows require numerous minerals, trace elements and vitamins to survive. The roles of minerals and vitamins have been discussed in Appendix 4, so only those implicated in fertility are mentioned here.

Calcium

Subclinical calcium deficiency in cows around calving can result in calving troubles, retained foetal membranes and inappetence. If correct, these effects could result in reduced reproductive performance.

If either milk fever or subclinical calcium deficiency is considered to be a problem, anionic salts could be used together with other dry cow management strategies. Cows due to calve should not be fed supplements containing sodium bicarbonate.

Magnesium

Supplementary magnesium fed to calving cows reduces the risk of grass tetany. It also reduces the incidence of milk fever. Some advisers recommend feeding supplementary magnesium to avoid subclinical calcium and magnesium deficiencies in cows at calving.

Phosphorus

Phosphorus deficiency has been shown to cause delayed onset of heat in some studies but not others. Phosphorus-deficient cattle can also be energy-deficient in some circumstances (eg during prolonged periods of underfeeding). In these situations, effects of phosphorus deficiency cannot be readily determined.

In early lactation, phosphorus supplied in the many forages is insufficient to meet cows' requirements. Affected cows then use their bone reserves of phosphorus. This may be sufficient to prevent reproductive performance being affected.

Selenium

There are numerous reports of retained foetal membranes due to selenium deficiency.

Detecting deficiencies

Laboratory tests are available for many minerals and trace elements. Although some tests are useful, the results of other tests are not highly correlated with responses to treatment. In other words, even if testing indicates a deficiency, supplementation does not always produce an improvement in animal performance.

Feed analyses might help to estimate an animal's current intake of certain elements, but there are some drawbacks:

- results will vary between feed batches and even between fields on the same farm
- grazing cows select their forage, so sampling has to mimic this in order to estimate what is actually being eaten
- feed intake has to be estimated
- minerals interact with each other – requirements for most minerals and trace elements depend on the amount of other minerals and trace elements present
- meaningful interpretation of feed analyses for minerals and trace elements is not simple.