8

Best management practices on large-scale, intensively managed dairy farms

This chapter presents an overview of the essential on-farm practices necessary to effectively run a large-scale intensive dairy farm in the humid tropics to sustainably produce a consistently saleable product.

The previous chapter (7) discussed the Best Management Practices (BMP) specific to smallholder dairy (SHD) farmers. Many of these were grouped into a series of Golden Rules, for ease of developing farmer capacity building programs under the auspices of the Smallholder Dairy Development Program (SDDP). As the BMPs don't greatly differ for small or large-scale dairy farmers, this chapter will not repeat much of Chapter 7, only concentrating on those aspects that are particularly relevant to large-scale intensive dairy farming.

Section 7.1 in Chapter 7 on the importance of record keeping on dairy farms applies equally to large-scale farms as it does to smallholder farms, so should be read and practised in conjunction with the contents of this chapter. It is highly likely that management of large-scale dairy operations will have developed their own system of record keeping, particularly if they have the type of electronic cow monitoring system described in Section 5.6.2 in Chapter 5.

8.1 Forage production

As it is cheaper to grow quality forages on-farm, generally the less purchased, the lower the feed costs. With well-planned dairy production systems, it should be possible to supply 95 to 100% of the forages from on-farm supplies, through strategies such as fodder conservation. Strategic purchases of small quantities of very cheap, lower quality forages (such as rice straw) for stock with lower daily nutrient requirements, such as dry cows, may still be a good management decision.

The key issues to ensure high yields of quality forage from any forage crop are:

- Preparation of the soil for sowing, to ensure a good establishment of the crop and minimum weed invasion.
- Fertilising the crop with sufficient soil nutrients, using inorganic fertilisers to supplement dairy shed effluent. Ensure fertilisers are routinely applied after every (or at least every second) forage harvest.
- Developing a crop-harvesting program to ensure quality forage as well as adequate forage yields.

Fertilisers cost money, but they return more through improved yields and quality of forage, hence more milk. Provided other soil nutrients are not limiting plant growth, urea fertiliser can produce an extra 9 kg forage dry matter (DM)/kg urea or 18 kg DM/kg N applied. When harvested and fed to milking cows, this extra forage can yield an additional 9 kg milk/kg urea N (STOAS 1999).

One major limitation of forage production on most dairies throughout tropical Asia is the poor adoption of inorganic fertilisers. Use of cow manure only to fertilise grasses is common practice in most dairying areas in Asia because many farmers are not even aware of the economic gains achievable through using inorganic fertilisers. Cow manure supplies organic matter to the forage area, but insufficient N to maximise forage yields and quality. Dairy farmers should apply at least 100 kg urea/ha/yr to their forage production area, in addition to the recycled manure.

The general recommendations for moderate milk yields (10 to 15 kg/cow/day) in 450 kg dairy cows consuming 13.5 kg DM/d, is for Napier grass containing 8 to 13% protein and 7 to 8 MJ/kg DM of metabolisable energy (ME). This can be supplied from forage harvested at 42 to 70 days, when 60 to 100 cm high, providing a carrying capacity is 4 to 4.5 cows/ha. For high milk production (< 15 kg/cow/d), harvest intervals would have to be increased to 30 days. Milk yields per ha would be high even with low carrying capacity, because of the reduced protein yields. The increased cost of more frequent harvestings and greater fertiliser applications to maintain soil fertility will reduce the economic benefits of the higher milk yields.

8.1.1 Stocking capacity

For a farmer growing the maximum quantities of quality forages, to feed his milking cows well, he should have no more than eight to 10 milking cows per hectare of forage grown on his farm. The derivation of these stocking capacities can be found in Chapter 20 of Moran (2005). However, most dairy farmers do not manage their forages well enough to produce the highest yields of forage. Therefore, a more realistic recommendation would be six to eight milking cows (plus the replacement heifers) per hectare of forage grown on-farm. Figures 8.1 to 8.3 show forage maize arriving at a dairy, the forage being put through a chopper and farmers examining the feed after processing.

8.2 Feeding management

8.2.1 Forage quality

To produce milk and calves, dairy cows require feed nutrients that are supplied through a combination of forages and concentrates. To produce acceptable milk yields, say 15 L/day, cows require a ration containing at least 10 MJ/kg DM of

Figure 8.1: Forage maize, contract grown by local farmers, being delivered to the North Vietnam dairy feedlot for ensiling.

Figure 8.2: Processing the North Vietnamese forage maize through a chopper before consolidating it in a large silage bunker.

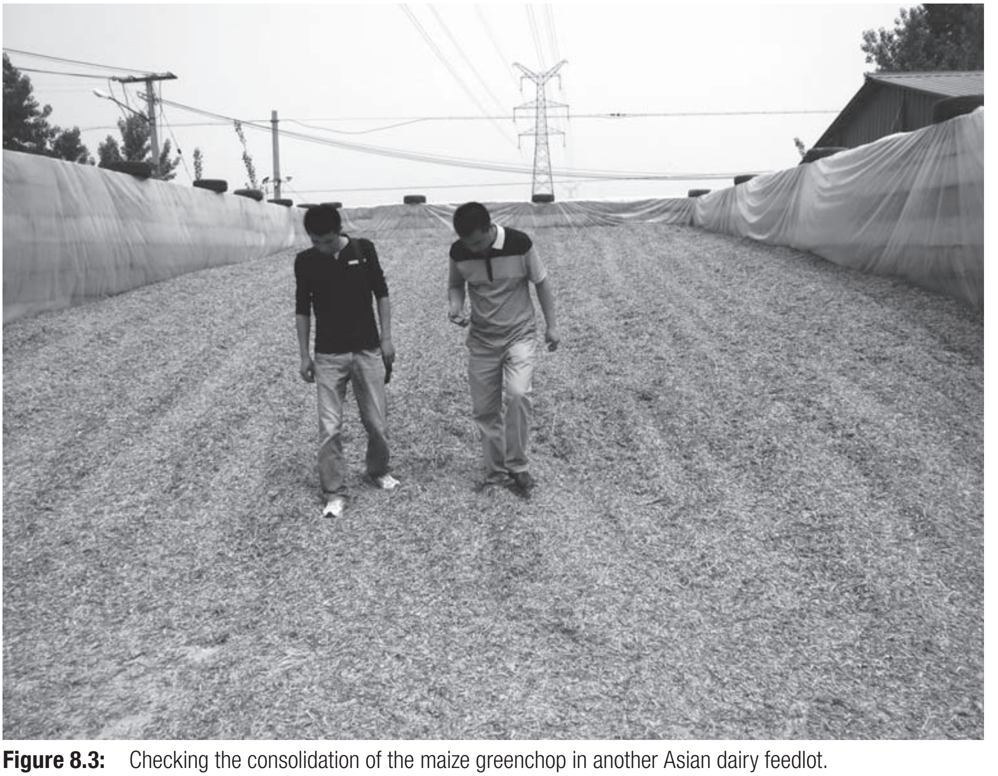

Figure 8.3: Checking the consolidation of the maize greenchop in another Asian dairy feedlot.

metabolisable energy (ME). The more ME that is supplied by forages, the less is required by concentrates. For milking cows, the recommended forage quality would be 9.5 to 10.0 MJ/kg DM of ME and 12 to 14% crude protein.

8.2.2 Concentrate feeding program

Concentrates should be formulated to provide adequate dietary nutrients to supplement available forages. The recommended concentrate quality would be 11 to 12 MJ/kg DM of ME and 16 to18% crude protein (CP), depending on milk yields.

Many Asian dairy advisers use a general 'rule of thumb' that farmers should feed 1 kg concentrate for every 2 L of milk produced. This is a safety measure because of the lack of knowledge on the nutritive value of the feeds, particularly the forages. It also provides supplemental energy to cows when fed only limited amounts of forage.

With knowledge of the feeding value and costs of the forages and concentrates, more objective and therefore better decisions can be made on how much concentrate should be fed to achieve target milk yields. This requires more knowledge and greater effort than following the 'feed 1 kg concentrate per 2 L milk' rule, but such decisions can greatly reduce total feed costs and so improve profitability, when expressed as milk income less feed costs.

8.2.3 Total feed costs

The choice of available feeds for milk production will differ from country to country, as do their relative costs. The principle of formulating profitable rations is to compare different feeds first on the basis of their cost per unit energy, because energy is nearly always the first limiting nutrient. When protein deficiencies limit cow performance, the unit cost of protein becomes important. The fibre content of each potential feed ingredient is considered just to make sure the cows' appetite will not too restricted and they will not eat all that is offered.

When formulating rations, either by computer or by calculator, as long as farmers are confident that the raw data (feed costs and nutritive values) are representative of that feed being fed to those cows, then traditional ration formulation calculations, such as those presented by Moran (2005), will provide a meaningful answer to any least-cost ration. With experience, the process is less time consuming because 'best bet' rations can be easily checked for their nutrient content and likely milk yield response.

8.2.4 Milk income less feed costs

Milk income less feed costs (MIFC) is one of the simplest indicators of farm profitability. In addition, changes in MIFC are quick to monitor because of the rapidity with which milking cows respond even to small variations in their feeding management. When introducing new feeds into the diet or varying their amount, the cows' milk responses will reflect these changes within a few days as will their

MIFC within a week or two. The development of generic indicators for total feed costs and MIFC depend greatly on the base costs of feeds in different dairy regions. MIFC is also known as Feeding Profit and to aid its calculation, the senior author has developed a computer program called INDOFEEDPROFIT, which will be discussed in Chapter 11, Section 11.4.2 of this manual.

8.2.5 Pattern of milk production

The three major factors determining total lactation milk production are the lactation length, the peak lactation yield (within 6 to 8 weeks post calving) and its rate of decline from this peak (or lactation persistency). Persistency will be discussed in Section 8.7.5 of this chapter.

8.3 Young stock management

Poor heifer management is a major problem in many (if not most) Asian dairy farms (both large and small). Farmers give insufficient attention to young stock because they do not generate income for many months until after they first calve down. In addition, the first three months are the most expensive period in the life of any dairy cow and many farmers are just not prepared to invest in the calves' future. A low calf mortality rate indicates that early milk rearing practices are adequate, hence will provide greater opportunities for economic and genetic improvement in the herd.

There are easily quantifiable benefits in having more newly calved heifers available to replace older unprofitable cows, as heifer and reproductive managements improve. These benefits are for:

- every month reduction in age at first calving; 1 to 2% more first calf heifers
- every 10% reduction in calf mortality; 3 to 5% more first calf heifers
- every month reduction in inter-calving interval; 2 to 3% more first calf heifers.

Farmers should aim to rear 20 to 25% of their milking herd each year as replacements, to calve down for the first time by about two years of age and produce at least five calves during their productive life. Realistic targets for Friesians in tropical dairy systems are:

- Calf mortality to weaning, 4 to 6%.
- Heifer wastage rate from birth to second calving, 20 to 25%.
- Live weight at mating, 250 to 300 kg.
- Live weight at first calving, 400 to 500 kg (depending on breed type).
- Age at first calving, 24 to 30 months.

Another good indication of heifer management is first lactation milk yield, expressed as % of mature cow production, with a target of 80 to 85%. If this is less than 75% of the mature equivalent, then the heifer-rearing program should be reviewed.

Wither height (or height at the shoulder) is a good measure of bone growth and potential body frame size in heifers. Frame size can influence ease of calving and appetite of milking cows. For Friesians, farmers should aim for wither heights of 115 to 120 cm by 15 months and 125 to 130 cm by 24 months of age.

8.3.1 Caring for the newborn calf

There are well 'tried and tested' procedures for managing newborn calves. These include:

- Making sure the calf is breathing by clearing the nose and mouth. If breathing is slow to occur, stick a piece of straw up the nose to stimulate breathing and if this fails then pour cold water over the calf's head, especially into its ear canal.
- Removing the calf from any contaminated bedding by providing clean bedding where the dam can lick the calf.
- Placing the calf into a dog sitting position to encourage breathing and disinfect the navel cord with 7% iodine solution at least once.
- The next steps can be summarised in three statements: *Get her up*, *get her dry and get her fed*.
  - ➤ *Get her up.* Encourage the calf to stand.
  - ➤ *Get her dry.* Allow the dam to lick the calf and/or vigorously rub the calf with a dry towel to create a dry fluffy coat.
  - ➤ *Get her fed.* Assist the calf to suckle from a clean teat so it can immediately drink colostrum.
- Minimise the possibility of pathogens entering the calf via two major routes, namely the mouth and the navel.
- Permanently identify each calf.
- Calves born from difficult calvings should be clearly marked to closely watch over the next few weeks.

In summary, for a normal delivery, a newborn calf should exhibit the following signs:

- The calf tries to lift its head within minutes.
- It rolls up on its sternum within 5 min.
- It attempts to stand within 15 min.
- It is standing within 1 hr.
- It suckles within 2 hr.

If calves do not exhibit these signs, chances are that the delivery is not normal and the calf requires assistance.

8.3.2 Managing the milk-fed calf

There is no single best way to milk-rear calves. All sorts of combinations of feeding, housing and husbandry can be successful in the right hands and on the right farm.

The essence of good calf rearing depends on two major nutritional factors. First, an adequate intake of high quality colostrum within the first day of life and, second, feeding management to encourage early rumen development.

Colostrum feeding

Calves are born with no immunity against disease. Until they can develop their own natural ability to resist disease, through exposure to the disease organisms in their surroundings, they depend entirely on the passive immunity acquired by drinking colostrum from their dam.

Colostrum is the thick, creamy yellow, sticky milk first produced by cows initially following calving, and contains the antibodies necessary to transfer immunity to their calves. It is essentially milk reinforced with blood proteins and vitamins. It has more than twice the level of total solids than whole milk through boosted levels of protein and electrolytes. It also contains a chemical allowing newborn calves to utilise their own fat reserves to immediately provide additional energy.

The chances of calves surviving the first few weeks of life are greatly reduced if they do not ingest and absorb these antibodies into their bloodstream. It takes far fewer disease organisms to cause disease outbreaks in such calves than if they can acquire immunity from their dam. Calves without adequate passive immunity are four times more likely to die and twice as likely to suffer disease, than those with it. Furthermore, in certain situations, blood levels of antibodies in heifer calves are directly related to their milk production in later life.

There are three key principles for colostrum feeding which can be summarised as the three Qs, namely:

- *Quality*. Only provide good quality colostrum.
- *Quantity*. Ensure calves ingest sufficient antibodies.
- *Quickly*. The timing of the first feed must ensure efficient absorption of the antibodies into the blood.

In summary, the important principles of good colostrum management are:

1. Use colostrum from mature cows that produce less than 8 L at their first milking.
2. Use only first milking colostrum, do not sterilise it but ensure the feeding equipment is clean and has been sterilised.
3. Feed 4 L to large calves or 3 L to smaller calves at first feeding.
4. Feed colostrum as soon as possible, at least within the first 3 hr after birth.
5. Do not let calves suckle their dams.

In summary, calves should have access to 4 L of colostrum within the first 6 hr of life. They may not need any additional milk for the next 12 to 24 hr. Any calf that is suspected of not having suckled in the first 3 to 6 hr should be hand-fed the colostrum. With sick or weak calves, colostrum may have to be administered by stomach tube. It is not difficult to stomach-tube young calves.

The longer calves spend with their dams, the greater their exposure to potential disease. Therefore, newborn calves should be separated from their dams as quickly as is practically possible.

Feeding milk to the calves

Calves require a diet of good quality whole milk or calf milk replacer (CMR). The choice of liquid feed should be based on its cost per litre and this depends on the milk returns for raw milk and the cost of the CMR powder. In many cases, CMR is the cheaper when diluted to a mixture of one part CMR and 10 parts water (or as per the manufacturer's recommendations). The CMR must be a good quality product to ensure calves can digest it properly.

Milk can be fed either through teats or directly from a bucket. There is no difference in the ability of the calf to utilise the milk fed either way (Moran 2012b). If calves are sucking each other, teat feeding may be necessary to control this. Milk can be fed once or twice a day as it clots in the calf's stomach after which it is slowly broken down by the calf's gastric juices. The milk does not have to be heated up before feeding. It is important that the milk concentration, timing and temperature remain consistent from day to day. Calves should be given free access to good quality drinking water from 1 week of age.

It is very important that calves are kept in clean pens and that hot water is available to clean milk-feeding equipment. One major health problem is scours, which results mainly from an inconsistent milk feeding program, poor hygiene and inadequate colostrum feeding. As many scours are not due to bacterial diseases, there is often little need to consider antibiotics in the treatment. Fluids and electrolyte replacement are the main requirements.

8.3.3 Other aspects of calf management

Try sleeping on concrete

Concrete is always hard with no soft spots in which calves can get comfortable. Calves lie down a lot, spending 95% of their time when newborn and slowly decreasing as they approach weaning age. We must manage stress associated with lying comfort by using enough bedding to buffer the typical hard pen base. Even in the tropics, newborn sick calves can suffer from cold stress and concrete transmits body heat very easily. Clearly calves need a clean and comfortable place to rest. Wooden slats are easy to clean but ideally they need some form of insulated bedding, such as straw or sawdust. In cold conditions, calves need to be kept dry, well ventilated with fresh air, no wind and be able to nest in long straw. Many calf-rearing systems have high ammonia levels close to the ground, so get your nose to ground level to check this, even if you think the ventilation is good.

The calf kitchen

A dedicated place, the calf kitchen, to clean and store all the milk feeding equipment will improve the efficiency and hygiene of managing the young calves. This includes storage of calf concentrates and roughage and, if being used, storage and formulation of calf milk replacer. All milk-handling containers should be rinsed with cool water, washed with warm soapy water, rinsed again then hung upside down to drain. The kitchen should include hot water, clean rinsing water, a sink and drying racks. If using fresh milk, the kitchen should be within easy access of the milking area.

Hot weather and calves

Calves subjected to hot weather change their behaviour by decreasing feed intake, increasing water intake, increasing time spent standing and of course respiration rates. Calf health is also affected by heat stress, such as rapid dehydration, while vaccines work less well or not at all and their immune system defences against infection are weakened. The first response is to drink more water, which increases by 30% as temperatures increase from 21 to 27°C and by 100% as they increase from 21 to 32°C. Calves with scours may suffer extreme dehydration very quickly. So we need to be extra vigilant in diagnosing and treating these calves.

To reduce the effects of heat stress, it is important to move as much air around the calves as you can using natural ventilation and fans. Leave the fans on all night to help remove excess body heat. Drinking containers should be kept clean and free from algae and mould.

Only handle the calves during their low heat-stress times, such as very early in the morning. The calves' peak body temperatures occur between 4 to 7 p.m., when we perceive the day to be cooling off.

Calves can tell you how they are feeing

If you are 'listening' with your eyes, sick calves can clearly communicate that they are not feeling well. The most common sickness behaviours are:

- Smaller flight zones. Sick calves will not instantly stand up or move away when approached and may even need more encouragement to get up.
- Less interest in people. Calves that receive their milk from people should display an eagerness to interact with them when they are approached. Calves that fail to take at least one step forward in the first 30 s after being approached are more likely to be ill.

- Posture changes. Standing with an arched back and tucked in tail for at least 60 s after it has risen, stretched and urinated is a demonstration of physical discomfort and possible ill health.
- Calf behaviours should be observed when they are relaxed because if they are startled or frightened, their survival instincts will override their feelings of sickness and make ill calves more difficult to detect. Watching for these signs every day will help to identify disease incidence early so treatment and supporting therapy can be delivered promptly and effectively.

Recognising sick calves

Other tips for sick calf identification include:

- Watch for calves that are drinking slower or not finishing their milk or milk replacer solution.
- Watch for calves spending more time lying or resting or eating less calf concentrate.
- Rapid breathing, fever, watery eyes, diarrhoea, signs of dehydration, nasal discharge or coughing are signs that a health challenge has already developed.
- The degree of dehydration can be assessed using the skin fold (pinch) test. Pinch the skin and note how long it takes to return to normal. In healthy calves, this is less than half a second whereas it can vary from 1 to 10 s in sick calves, depending on their degree of dehydration. Another indicator is the degree of sunkeness of the eyes.
- Look for calves doing something that all the other calves in the pen are not doing. Healthy calves should be bright and alert, active and energetic, eating, chewing and playing.

It takes more than just milk

When thinking of calves and what it takes to grow them properly, the main component of their diet is milk or milk replacer solution. However, it is important to think about the other diet components as well. Milk is fed to calves for only a limited period and the transition from milk to solid feed is relatively quick. To create a smoother weaning period and maintain growth post-weaning, it is important to encourage intake of more than just milk, even in the pre-weaning period.

The main question is what else should we be feeding the milk-fed calves? Concentrates only or forages as well? Given the choice, calves tend to prefer forages before weaning (as long as they are good quality and palatable) and concentrates after weaning. However, after weaning, a combination of concentrates and forages promotes the best growth rates.

Early rumen development

The rumen is non-functional in newborn calves; hence, all digestion must take place in the abomasum (or true stomach) and the small intestine.

The weaned calf needs a fully functional rumen in order to be well adapted to a forage-based diet.

Rumen development occurs through the digestion or fermentation of feeds (roughages and concentrates) by the rumen microbes. Calves should be encouraged to eat solid feeds at an early age, mainly through limiting their access to milk to 4 L/day. From the first week, roughage such as clean straw should be offered in combination with high-quality concentrates specially formulated for rearing calves. But concentrates are more important in developing rumen function.

A program for milk feeding

If calves are strong, healthy and kept warm and dry, they can be successfully reared on once daily feeding with 4 L of whole milk, or its equivalent in milk replacer. All calves should be offered a specially formulated calf meal from one week of age. Milking cow concentrate formulations do not contain sufficient protein to meet the needs of young calves.

All calves must be given the opportunity to nibble on the straw even though they will eat very little of it. If good quality hay is fed, it should be limited to 100 to 200 g/calf/day. Calves should have limited access to fresh forages.

Feeding milk only once each day helps the calves to develop an appetite for the concentrates. It is the concentrate rather than the milk that should provide the bulk of nutrients to keep the calf growing. Calves can be weaned off milk once they are consuming 0.75 kg/day of concentrates for two or three consecutive days. This usually occurs by about 6 to 8 weeks of age.

Ideally, young calves should be housed individually or in small groups. They should also be individually bucket-fed. There is no advantage in milk feeding using teats rather than buckets; it only creates extra work in keeping them clean.

Weaning age

The age when calves should no longer be fed milk also depends on the quality of feeds available. They should be weaned at:

- 2 months, when quantity and quality of roughage and concentrates are good
- 4 months, when quantity and quality of roughage and concentrates are average
- 6 months, when quantity and quality of roughage and concentrates are poor
- 8 months, when suckling and cows are dried off.

It must be stressed that the cost of milk feeding, either the loss of income from these milk sales, or the cost or purchasing and mixing calf milk replacer, must be considered when considering delaying weaning age.

Concentrate quality

Milk-fed and weaned calves require concentrates containing higher protein levels (18–20%) than do milking cows (16%). Low protein concentrates will not promote the same rate of rumen and body development in milk-fed calves. Consequently weaning such calves at 2 months old may be too early.

The high cost of milk rearing

Many Asian farmers feed milk (or milk replacer) to their calves for 8 to 10 to 12 weeks. This is the 'accepted method' because the high nutrient intakes in milk should ensure a good growth rate, provided the calves remain healthy. This method is common where specially formulated calf concentrates are not readily available.

However, feeding high levels of milk can cause several problems. First, it is invariably more expensive to provide the same intake of feed nutrients from milk or milk replacer than from formulated calf concentrates.

The second problem is the increased likelihood of disease. Once milk is removed from their diet through weaning, calves are more resistant to scours. Unless a strict cleaning and sterilising routine is enforced in the calf shed, flies and other disease-carrying agents will thrive on residual milk left in buckets, on floors and in other equipment used with milk feeding.

8.3.4 Management of weaned replacement heifers

Weaned growing heifers require less attention than milk-fed calves and milking cows. From weaning until breeding and sometimes even after then, daily contact is not necessary. Because their nutrient requirements are relatively low compared to milking cows, heifers may be located away from the dairy farm, sometimes on agistment on other farms. Unfortunately, the saying 'out of sight, out of mind' applies too frequently to replacement heifers. This relative neglect is understandable in view of the long time it takes before any inadequacies in post-weaning practices are reflected in poor milking cow performance.

Dairy heifers need to be well fed between weaning and first calving. Growth rates should be maintained, otherwise heifers will not reach their target live weights for mating and first calving. Undersized heifers:

- have more calving difficulties
- produce less milk
- have greater difficulty getting back into calf during their first lactation
- when lactating, they compete poorly with older cows for feed
- because they are still growing, they will use some of their feed for growth rather than for producing milk
- they are more likely to be culled for poor milk yield and/or infertility.

The onset of puberty is related to weight rather than age. A delay in puberty means a later conception, which can disrupt future calving patterns and increase rearing costs. All heifers should reach a minimum weight before joining, as lighter heifers have lower conception rates. Target growth rates should be 0.6 to 0.7 kg/head/day.

Although replacement heifers are essentially non-productive animals, some expenditure is necessary. They represent capital and investment in the dairy herd's future. Heifer rearing should achieve the maximum return on this investment with a minimum of outlay. It should not be regarded as a haphazard undertaking, which hopefully will produce a pregnant heifer, but rather as a business enterprise with clearly defined goals such as:

- the number of animals to be reared
- their desired age at first calving
- their target live weight at calving
- their feeding program
- ways to monitor their performance and total rearing costs
- any specific housing and health requirements.

When rearing dairy replacement heifers, producers should have five major objectives:

1. The maintenance or expansion of herd size. Heifer rearing systems should provide sufficient animals to replace cows culled from the milking herd and allow for increases in herd numbers if required.
2. Calving by 24 to 30 months of age. Entry into first lactation by 24 months of age minimises the total non-productive days and maximises lifetime productivity.
3. Sufficient growth for minimal dystocia (that is calving difficulties) at first calving. Heifers need to be large enough to calve without difficulty.
4. Maintenance of health. The prevention of clinical and subclinical disease plays a large role in the ability of replacement heifers to meet live weight and age targets at first calving. Longevity and lifetime productivity is also affected.
5. Genetic progress. Replacement heifers generally have higher genetic merit than the current milking herd. This can be expressed as increased productivity (both milk volume and solids), improved efficiency of production and/or enhanced resistance to disease.

Heifer rearing is not cheap and the costs to produce a lactating first-calf heifer can account for 15 to 20% of the total milk production costs. It is not good economics to cut back on heifer-rearing costs as lifetime profits will be reduced. The costs of heifer rearing are discussed in Chapter 11 at Section 11.4.3.

The number of first calving heifers each year will depend on the replacement rate within the milking herd. This is the sum of the wastage rate caused by infertility, lameness, mastitis, low milk yield, old age, accidents etc., together with the particular voluntary culling policy for that herd, whether this is to improve milk yield, feed efficiency or reduce calving interval. The number of heifer replacements to be reared also depends on mortality rates during rearing, the conception rates at first mating and the proportion of heifers reaching target weight for ages.

With two to three heifers per 10 cows introduced into the milking herd annually, at least 80% of the milking cows should be mated (either using a bull or artificially insemination) to obtain that number of replacements each year. When determining the total number of calves to rear, consideration could be given to rearing additional heifers for sale to other dairy farmers and/or bull calves for dairy beef.

On well-managed farms in temperate dairy regions, achieving a consistent calving program, requires heifers to:

- reach puberty at ~12 months of age
- become pregnant at 14 or 15 months of age
- calve at 24 months of age
- return to oestrus and be mated within 70 to 80 days of calving.

8.3.5 In summary

Benefits of heavier heifers

Provided heifers are at least 18 months old, the younger the heifers calve, the higher their first lactation and mature milk yields, the more calves they produce and the longer their productive life in the herd. An additional benefit is a more rapid generation interval, and hence a faster rate of genetic progress in the milking herd. Lifetime productivity reaches a peak in heifers calving at 25 to 27 months of age. For example, Friesian heifers calving at 24 to 27 months of age can produce 21 000 L milk over a 7-year productive life on established temperate dairy farms, compared to 18 750 L if calving at 30 to 33 months and only 17 000 L if calving at 36 to 42 months of age.

Several long-term studies have documented the long-term benefits from heavier calving weights in Friesian heifers. For every additional kg at first calving, heavier heifers can produce 7 L extra milk in each of their first three lactations. Therefore, if heifers calved at 500 kg compared to 450 kg, they would produce an extra 350 L milk/lactation or 1050 L extra milk over their first three lactations.

Calves that are poorly managed before and after weaning are disadvantaged for their entire life. Even if they are well fed after mating, their ultimate mature size is restricted and if they do put on extra weight, it tends to be fat. Most of the growth in skeletal size occurs before, not after puberty.

Dairy heifers need to be well fed between weaning and first calving. If growth rates are not maintained, heifers will not reach their target live weights for mating and first calving.

Undersized heifers have more calving difficulties, produce less milk and have greater difficulty getting back into calf during their first lactation. When lactating, they compete poorly with older, bigger cows for feed. Because they are still growing, they use feed for growth rather than for producing milk.

Poorly grown heifers do not last long in the milking herd. They are more likely to be culled for poor milk yield or poor fertility during their first lactation.

Targets for replacement heifers

Traditional target weights are too low to ensure first lactation heifers achieve their productivity potential, particularly on farms where milking cows are well fed. Friesian crossbred heifers should weigh 280 to 340 kg with wither (shoulder) heights of 115 to 120 cm at mating then 450 to 500 kg with wither heights of 133 to 135 cm at calving.

Feeding heifers to achieve target live weights

Producers should regularly weigh or monitor their young stock, and then vary feeding strategies according to their growth rates. Growth in Friesians should average 0.6 to 0.7 kg/day, although that can vary between 0.5 and 1.0 kg/day, depending on available forage and the supply and cost of suitable supplements.

As fresh forage is the cheapest feed, it should constitute the bulk of the diet, with silage or hay and concentrates used to overcome forage shortages. Until calves reach 200 kg in weight, they are not able to maintain the growth rates needed to reach target weights on diets of most forages. Their capacity is limited and they simply cannot eat enough forage to meet their nutrient requirements for rapid growth.

Forage quality and allocation should allow for continuous growth throughout the first two years. Uniform growth is not necessary and may be impracticable with seasonality of quality forage supplies. However, heifers should not be allowed to lose weight or to grow very slowly for long periods of time.

8.4 Disease management

The three biggest animal health problems on Asian dairy farms are lameness, mastitis and scours in milk-fed calves. Treatment, control and management practices for these disease problems have been discussed in detail by Moran (2012a).

8.4.1 Health and reproductive performance

There are many health management problems that can adversely affect fertility, such as:

- management of twin calves
- assisted calving
- Retained Foetal Membranes (RFMs)
- uterine infections and vaginal discharges

- lameness
- ketosis
- displaced abomasum
- cystic ovaries
- abortions.

Some health problems affect the reproductive tract directly (such as RFMs and vaginal discharges) while others reduce feed intake leading to rapid body condition loss and anoestrus (such as lameness and ketosis). It is important to keep good records and have a planned approach for treatment and prevention.

Cows with problems at calving have an increased risk of infection of the reproductive tract. Such infections can last for weeks (even months) after calving and can even show normal heats and no abnormal discharge, yet these cows can have reduced fertility. They may cure themselves over time but are more likely to show repeat heat cycles. As well as immediate treatment, follow-up treatments are available such as prostaglandin or antibiotics.

To improve cow health, it is important to keep accurate records and seek veterinary advice if the percentage of naturally calving cows (excluding cows induced to calve early) with this problem exceeds the number shown in brackets below:

- any cow having twins (no practical strategies prevent twin calves)
- any assistance required to deliver a calf (seek advice if > 6%)
- any calf born dead or died within 24 hr of birth (seek advice if > 1%)
- RFMs, that is membranes visible externally on the day of calving (seek advice if > 4%)
- vaginal discharge or pus discharging from the vulva more than 14 days after calving (seek advice if > 6%)
- lameness, or cows not bearing full weight on at least one leg which affects walking (seek advice if > 3% of first calvers or > 2% of older cows)
- abortions (seek advice if > 5%)
- other health problems, including ketosis, displaced abomasum or cystic ovaries (seek advice if > 5%).

Some infections that cause abortions in cattle can also infect humans, so:

- only handle aborted foetuses and membranes with disposable gloves
- avoid contact with vaginal discharges from aborted cows
- bury the foetus and membranes ensuring that dogs are not allowed access to them.

8.4.2 Biosecurity when purchasing new stock

Most dairy farmers purchase new stock during the farm establishment process. Therefore, it is important to carefully plan the introduction of stock to minimise the risk that they will introduce infectious diseases. The factors shown below are important in reducing this risk.

When purchasing new stock:

- ensure their health status is known
- where possible, ensure details of their vaccination program are known
- avoid purchasing stock from unknown sources or stock that have mixed with other cattle before sale
- purchase heifers because they can be more easily quarantined and are less likely to have mastitis
- calves purchased should be kept separate for at least a week with no signs of disease
- transport purchased cattle preferably in the farmer's vehicle, in a clean truck or trailer
- quarantine them in an area separate from other cattle on the farm
- use a medicated footbath before allowing them to enter the herd
- vaccinate them during the quarantine period to make sure they are integrated into the farm vaccination program.

Other biosecurity measures that should be considered include:

- controlling the movement of people, animals and equipment onto the farm
- as some diseases are spread on clothing and boots, if equipment is borrowed from other farms, it should be cleaned before use
- keep transport or service personnel away from the main herd area, especially the calf shed, or at least provide them with footwear.

8.5 Reproductive management

8.5.1 A framework for improved fertility

There are six factors that have large influences on herd reproductive performance. Three are non-nutritional and three are nutritional. They are:

1. The length of the *voluntary waiting period*, that is the number of days delay after calving before farmers begin inseminations. This is 50 to 55 days in herds with the best fertility.
2. *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.

3. *Artificial insemination* (AI) practices. Good first insemination rates were 45 to 48%.
4. *Body condition*. Cows calving at condition scores of 3 (where 1 = emaciated and 5 = extremely fat) had higher 100-day in-calf rates (54%) than those calving at less than 2 (41%). Cows calving in very high score (4 or more) may lose condition more rapidly after calving and can suffer reduced fertility.
5. *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%.
6. *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.

For year-round calving herds, there are four useful measures of reproductive performance. These are detailed below.

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 ~13 months of their previous calving. High 100-day in-calf rates lead to fewer cows with long intervals between calving and fewer cows culled as non-pregnant. Cows that conceive within 100 days of calving will calve again within 12.5 months and generate higher profits than cows that take a longer time to conceive or fail to get pregnant. This measure usually allows for the voluntary waiting period (the days between calving and the first mating) of say 55 days plus two oestrous cycles of AI (say 42 days) before the cow is put out for natural mating.

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 no more than 15 to 16 months after their previous calving. This coincides with six months after which non-pregnant cows are often culled. It cannot be calculated until many months after cows have calved, but because it is closely related to the 100-day in-calf rate, it can be estimated from that measure. It cannot be calculated unless the whole herd is pregnancy tested.

Submission rate

This is the percentage of the herd that 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 with minimum delay after calving. An 80-days submission rate is the percentage of cows that receive at least one insemination by 80 days after calving.

Conception rate

This is the number 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. Sometimes the first insemination conception rate is calculated by including only the first services after calving in the analyses.

For a milking herd in Asia, target KPIs for reproductive performance are:

- 100-day in-calf rate; 55 to 60%
- 200-day not-in-calf rate; 13 to 15%
- submission rate; 65 to 70%
- voluntary waiting period; 50 to 60 d
- conception rate to first insemination; 45 to 50%
- inseminations per conception in an AI program; 1.8 to 2.0.

These measures of reproductive performance are rarely used in Asia, because they require routine pregnancy testing of the entire herd. More typical ones are:

- days from calving to first service; 60 to 80 d
- inter-calving interval; 12 to 13 months.

8.5.2 Combined measures of reproduction and calf survival

Table 8.1 presents measures of reproduction and calf survival in two rearing systems, to calculate their relative replacement rates for a dairy herd with stable stock numbers. System A measures could be considered as a set of key indicators.

Table 8.1. Measures of reproduction and calf rearing to produce replacements for a stable dairy herd.

Rearing system	A	B
Calving interval (m)	12	18
Calving rate (%)	85	65
Stillborn calves (%)	2	5
Calf mortality from 0–24 m (%)	8	20
Non-pregnant heifers (%)	5	10
Heifer calves born (%)	36	15

Assuming cows remain in the milking herd for four to five lactations, 20 to 25% should be replaced each year. From Table 8.1, the supply of 36% heifers from System A allows for the sale of young breeding stock or a higher culling rate to better address genetic improvements in the herd. Only one in every six or seven cows could be replaced annually in System B, which would hardly be enough to maintain herd numbers, let alone allow for much genetic selection.

With high ages at first calving (> 30 months) and long inter-calving intervals (> 15 months), it is very difficult to increase herd size through natural increase. That is why it is so important to seek the underlying causes of herds with high percentages of dry cows or a high proportion of heifers to cows. The most likely cause is poor feeding management but there could be others, such as disease, heat stress or simply poor reproductive practices.

8.6 Cow comfort; what it is and why it is so important

'Cow comfort' is a relatively new term that is being more commonly used to describe 'how a cow is feeling' about her surroundings. Some people just think of it as the type of bedding material available when the cow wants to lie down and rest. Others use it to describe the climatic environment, that is the zone of thermo-neutrality or the 'comfort zone', in which cows don't need to use their physiological processes (such as shivering or increased respiration rate or sweating) to maintain their body temperature. Others consider it is more related to the cow's ability to do what they want to do and when they want to do it. It is generally agreed that cow comfort should also be extended to its psychological as well as its physiological wellbeing. Therefore, the complete definition addresses climate stress, poorly designed and constructed housing, stock facilities and the potential behavioural stress arising from herd mates and stock people.

Whatever it is, the most important thing is that it does not upset the cow's appetite for feed or water. Feeding management is devoted to ensuring the quality and palatability of the forage and concentrates are the best possible, so the last thing farmers want is that cows do not want to eat what they are offered. In the tropics, the key to ensuring cow comfort is addressing heat stress issues.

8.6.1 Heat stress in milking cows

The comfort zone for milking Friesian cows is between 6 and 18°C. Between –5 and +5°C, appetite will be stimulated while at the upper level, above 27°C, appetite is depressed and both biological and economic efficiencies decline. Above 24°C, dry matter (DM) intake decreases by ~3% for every rise of 1.2°C.

As cattle have a limited ability to sweat, the main route of heat loss in cattle during hot weather is evaporative cooling from the respiratory tract, namely the nasal passages and lungs. Cattle then increase their breathing rate to increase movement of air over the moistened surface of the upper respiratory tract and mouth. However, if humidity levels are high, the effectiveness of this evaporative cooling is decreased and cattle may be unable to dissipate accumulated body heat.

Clinical signs of heat stress

The following signs can be used to assess the degree of heat stress:

- mild heat stress: drooling, increased respiration to 80–100 breaths/min
- moderate heat stress: drooling, respiration of 100–120 breaths/min and occasional open mouth panting
- severe heat stress: drooling, respiration rate greater than 120 breath/min and open mouth panting with tongue out. Cattle also have an agitated appearance, hunched stance and will often have their head down
- cattle can move from mild to severe heat stress very quickly, within 30 min to a few hours. Therefore, extra vigilance is required once mild heat stress is detected.

8.6.2 The Temperature Humidity Index and other measures of heat stress

Temperature Humidity Index

Heat stress occurs through a combination of high ambient temperature and humidity and other factors such as poor ventilation and high levels of internal body heat production.

The best single measure of heat stress is the Temperature Humidity Index (THI) as this combines temperature and relative humidity into a single comfort index. The relationship between temperature and humidity is presented graphically in Figure 8.4 and also in tabular format in Appendix 1. The higher the index, the greater the discomfort, which occurs at lower temperatures for higher humidities.

Its effects on cow performance are summarised in Tables 8.2 and 8.3. An air temperature of 30°C corresponds to a mild THI of only 74 at 25% humidity or 78

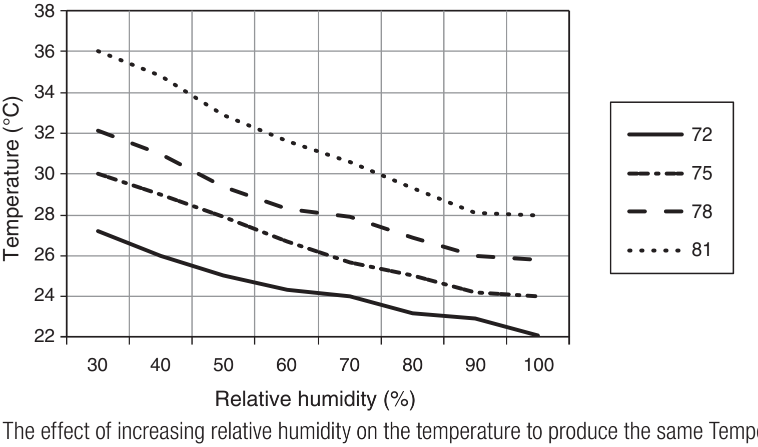

Figure 8.4: The effect of increasing relative humidity on the temperature to produce the same Temperature Humidity Index (THI).

at 50% humidity whereas it produces a severe heat stress (THI 82) when recorded at 75% humidity, a quite common occurrence in the humid tropics. For milking cows, an air temperature of 35°C equates to severe heat stresses (THI 80) at 25% and (THI 85) at 50% whereas it produces a very severe heat stress (THI 90) at 75% humidity.

Table 8.2. Effects of Temperature Humidity Index (THI) on dairy cow performance.

Comfort zone	THI	Stress	Comments
A	< 72	None	–
B	72–78	Mild	Dairy cows adjust by seeking shade, increasing respiration rate and dilution of blood vessels. Cow performance is adversely affected with reproduction more so than milk yield.
C	78–89	Severe	Both saliva production and respiration rates increase. Feed intakes decrease while water intakes increase. Milk production and reproduction are both reduced.
D	89–98	Very severe	Cows will become uncomfortable due to panting, high saliva drooling and high body temperatures. Milk production and reproduction will markedly decrease.
E	>98	Danger	Potential cow deaths can occur.

Table 8.3. Effects of Temperature Humidity Index (THI) on measures of cow heat stress.

Level of heat stress	THI	Respiration rate exceeds (no/min)	Body temperature exceeds (°C)
Zero	68	60	38.5
Mild to moderate	70	75	39.0
Moderate to severe	80	85	40.0
Severe	90	120–140	41.0

Some people argue that today's high-producing dairy cows begin to feel the effects of heat stress more quickly than was previously thought. In fact milk yield losses can become significant when the minimum THI on any given day reaches 65 or higher. Therefore, rather than set artificial cooling (say with fans and sprinklers) to begin when the THI reaches 72, they set the threshold to 65 to commence cooling at 65 to help cows deal more effectively with heat stress.

THI only quantifies the effects of air temperature and relative humidity, hence it neglects the other important aspect of heat stress, namely air movement. This was recently exemplified when the senior author visited a large dairy feedlot in the coastal lowlands of North Vietnam, only 40 m above sea level. In this 600-cow farm, the milking cows were kept in tunnel ventilation sheds whereas the young stock lived in non-tunnel ventilation sheds that depended entirely on internal fans and sprinklers. Data on temperature and humidity were collected every day at various times each day. The 2 p.m. THI data for the two types of sheds were plotted against the date. The average monthly THI inside the tunnel shed was the same as that inside the non-tunnel ventilated shed each time it was measured at 2 p.m. Mean monthly THI at 2 p.m. varied from 87 (in May) to 70 (in December).

In contrast to these observations, were others made in East Java in Indonesia at a large dairy feedlot that was located at 1200 m above sea level. At 9.30 a.m., the THI inside one of their tunnel ventilation sheds was 72 compared to 76 outside this shed. Being higher, the air was cooler inside compared to outside this shed, namely 24 v 28°C in May. In contrast to this, the Vietnamese shed was much hotter, with mean monthly 2 p.m. temperatures in summer (May to Aug) varying from 30 to 37°C. The impact of altitude on air temperature, which decreases by 6.5°C per 1000 m, meant that the outside air temperatures at the East Java feedlot would have been up to 10°C cooler than the Vietnamese feedlot, which in the morning would have increased the efficiency of the tunnel ventilation through considerably cooler air being forced through the input fans.

Therefore, people can quite rightly argue that THI may not be the best single indicator of heat stress. Another argument against THI is that since it only records the conditions at any one point in time, it cannot take into account any build-up in heat loads previous to the recording. One such Index has been developed for humans to do just this. The Accumulated Heat Stress Index accumulates the hourly heat stresses for 72 hr using time-weighted mathematical functions. Another index has been developed specifically for grazing dairy cows which takes radiative heat load into account. The Dairy Heat Load Index takes wind speed and direct solar radiation into account as well as temperature and humidity. This is not really relevant to intensive dairy systems based on feedlotting in sheds where radiative heat load is much less of an issue.

Heat Load Index

This is a new measure of heat stress developed specifically for feedlot beef cattle that are normally kept in dirt yards with minimal shade. It is based on a combination of:

- black globe temperature, which is a measure of the radiation heat load, taking into account both the ambient temperature and solar radiation
- relative humidity
- wind speed.

This index includes several adjustment factors such as genotype, coat colour, access to shade, water temperature in drinking troughs, and whether the animals are sick or healthy. Use of this index over time allows for the calculation of an accumulated heat load and the required heat loss during the night to maintain zero heat balance. However, developing such a Heat Load Index for Asian dairy cows normally maintained in sheds, is unlikely to provide an additional useful management tool.

8.6.3 Adverse effects of heat stress

For Friesians producing 20 kg/d, a THI above 78 leads to a decline in milk yield. There is also a decline in milk composition (milk fat and milk protein contents) but this occurs at 1–2°C higher than corresponding break points for milk yield.

With regard to reproduction, this declines before milk yield, namely, at THI of 72. Cows in early pregnancy (up to 3 weeks) can abort while cows in mid-pregnancy can have reduced birthweights. Cows are also more likely to have shortened and/or silent heats (less than 8 hr). Heat stress delays heat (hence submission rates) and, at the time of insemination or during the following 3 to 5 weeks, it can reduce conception rates and increase embryo mortality. By comparing conception rates between seasons (hot v cool or wet v dry), heat stress may be diagnosed as a problem if seasonal conception rates differ by more than 10–12%.

Severe heat stress will increase body (rectal and uterine) temperatures which in turn have a direct effect on reproductive performance. When rectal temperatures increase by 1.0°C within 12 hr after insemination, pregnancy rates can drop by 16%. An increase in uterine temperature of 0.5°C on the day of, or the day after, insemination can decrease conception rates by 13% and 7% respectively.

Cows are particularly vulnerable at temperatures above 30°C or, above 25°C with high humidity. Cows producing more than 15 kg/d of milk are more susceptible to heat stress due to their higher metabolic heat load. Zebu cows are less susceptible than Friesians because of their dense flat coat and higher density of sweat glands, however, exactly how less susceptible they are has not been documented. When planning strategies to minimise heat stress, it is then important to give priority to non-pregnant cows, usually in early lactation.

However, recent studies with transition cows (non-lactating and heavily pregnant) have shown that even though heat stress may not greatly reduce their voluntary feed intakes, it reduced subsequent milk yields by up to 10 kg/cow/day. This was attributed to a reduced inability of these cows to partition their body tissues towards milk synthesis during early lactation. Furthermore, the calves born from these heat stressed cows had lower birthweights, reduced growth of mammary cells during early udder development, which led to them also producing less milk, by up to 5 kg/cow/day, in their future lactations.

Recent surveys of the seasonality, particularly the adverse effects of high THI, on dairy cow performance in the United States, have shown marked adverse seasonal impacts on calf birthweight, yields of liquid milk and milk protein as well as conception rates and early foetal losses in pregnant cows. The study also highlighted the threshold THI for death rates of mature Friesian cows. Above the daily minimum THI of 70 and/or the daily maximum THI value of 80, there was a break point (indicating a sudden increase) in the incidence of Friesian cows dying, presumably from the additive adverse effects of heat stress. It is of interest that these values have decreased in recent years because of the improved genetic merit of dairy cows worldwide to produce more milk and the increasing number of hours per day that they are likely to experience heat stress (Young 2015). Some people might argue that this is the result of recent evidence on global warming.

In addition to reducing appetite, and hence milk yields, heat stress in milking cows has been shown to decrease lying times, reduce the proportion of saliva reaching the rumen and so affect its pH (thus making the cows more susceptible to subclinical rumen acidosis) and also impair reproductive success (both greater pregnancy losses from 21 to 30 days of gestation and more inseminations per successful conception), while increasing the time spent drinking, the incidence of lameness, hence cull rates and even cow mortality rates. It also changes the type of energy metabolism in the cow by reducing body fat mobilisation and increasing muscle breakdown, which would reduce the cow's ability to stimulate milk production in early lactation through repartitioning energy from body reserves to the mammary gland.

More recent evidence indicates that heat stress can have long-term detrimental effects during the cows' dry period. Heat stressed dry cows have depressed appetites, they lose more body condition and have a reduced immune function to combat disease/infections. Their milk yields are also adversely affected during their next lactation. In addition to this, the calves born to these heat stressed cows have lower birthweights, growth rates and reduced immunity, through lower absorption rates of maternal immunoglobulins from the colostrum to their blood stream, which has led to higher pre-pubertal culling rates. This is associated with adverse long-term effects of lower milk production and more inseminations per successful conception as mature cows. These recent findings clearly indicate the importance of paying much closer attention to heat abatement procedures in pregnant, dry cows (Young 2015).

Mating heifers can respond to heat abatement following just 4 h cooling using fans and sprinklers. This has been shown to increase their pregnancy rates from 23% to 57%. Herd bulls are also adversely affected by heat stress through reduced spermatozoa counts; this occurs 6 to 8 weeks following the heat stress period.

Adverse effects of heat stress are delayed by several days. The effect of mean THI two days earlier has the greatest influence on milk yield, while the effect of mean temperature two days earlier has the greatest influence on feed intake. Another good 'rule of thumb' when assessing heat stress for dairy cattle is that air temperature (in °C) added to humidity (in %) should ideally not exceed 90.

Improvements in milk yields of up to 3 to 5 kg are possible through effective cooling strategies. For example, in the East Java tunnel ventilation shed mentioned previously in Section 8.6.2, which housed Friesian cows each producing over 30 kg/day, it was estimated that this additional cow comfort produced an additional 3 kg milk/cow/day. For the record, as a result of this dramatic improvement in cow milk yields, the management of this Indonesian dairy feedlot has since installed tunnel ventilation in every dairy shed on the farm.

The high humidities associated with high daytime temperatures in the humid tropics reduce the effectiveness of using water to cool the air, thus negating the beneficial effects of evaporative cooling. Increasing respiration rates are the cow's natural way to increase evaporation from the alveoli tissues just as actually wetting the cow's skin provides the best opportunity to reduce blood, hence body temperatures, through cutaneous evaporation. Obviously increasing air movement over the skin, using fans, is the best way to stimulate such cutaneous evaporation. Therefore, initially using fans, followed by complete saturation of the cow's coat, using a computer/mechanically controlled cycle is the most effective artificial method of dissipating heat stress.

From the above evidence, heat stress clearly adversely affects many aspects of the performance of our modern day, potentially high yielding, milking cows. Therefore, when developing dairy development programs in the humid tropics and setting target milk yields, consideration must be given to more than just the type of milking cow and its feeding management. Farm management practices and physical shed designs to minimise the adverse effects of heat stress, are of equivalent, if not greater importance, in achieving such target milk and fertility measures of cow performance.

Cattle breed can play an important role in heat stress management. For example, Jersey, Brown Swiss and Friesian x Jersey stock are much more heat tolerant that purebred Friesians, and with good management, can also produce high levels of milk production. So they should be considered more for use in tropical dairy farming. *Bos indicus* cattle and buffalo are also quite heat tolerant.

8.6.4 Overcoming climatic stress

Observing the behaviour of cows is important in deciding when to modify management. If respiration rates reach 70/min, milk yield and reproduction may be compromised; this corresponds to 39°C body temperature, in contrast to a normal body temperature of 38.5°C. It is likely that higher yielding cows have faster respiration rates, because of the extra body heat production associated with higher feed intakes and milk yields. Improvements in milk yields of up to 3 to 5 kg/d are possible through effective cooling strategies.

Management strategies to overcome heat stress include:

- use more heat tolerant breeds of dairy cattle
- sheds should be designed to maximise natural air ventilation through its aspect on the farm, height and slope of the roof and having open sides
- cows can be cooled with hoses, sprinkler systems and cooling fans
- outside yards will provide for better overnight cooling as well as assisting in heat detection

- as forages produce more internal heat than concentrates, the bulk of forages should be offered in the cool of the evening
- drinking water should be continually available to milking cows
- Appendix 6 presents plans for cooling systems for a free stall shed.

8.7 Other measures of herd management

8.7.1 Proportion of cows milking of those that have calved

One good measure of the performance of the milking herd is the proportion of cows actually producing milk. For herds with a 12-month calving interval, lactation length should be 300 days (for a 65 days dry period), so lactation length would be the calving interval less 65 days, meaning that 82% of the cows are milking at any one time with 100% calving rate. However, in most year-round calving systems, less than 75% of the adult cows are milking. The longer the dry period, the fewer cows milking at any one time. The number of cows milking as a percentage of the total cow herd is influenced by several factors, the most important being lactation length, inter-calving interval and calving rate. It is assumed that cows with a 12-month inter-calving interval were dried off 65 days before calving. It also assumes no cows were culled for poor fertility or production and there were no mortalities among the milking herd.

Another way to demonstrate the importance of having as many of the adult cows milking as possible is to calculate the % days any one cow is milking which is related to the herd's inter-calving interval, the length of the dry period, hence the average lactation length. This is essentially the same as calculating the % adult cows milking for 100% calving rate.

Suggested KPIs for percentage of cows milking of those that have calved are:

- 74%; excellent
- 60–73%; acceptable
- 50–59%; below average
- 40–49%; not good.

8.7.2 Proportion of cows milking in the total dairy herd

Another useful measure of the proportion of productive cows is the size of the milking herd as a percentage of the total dairy herd, which includes the milk-fed and weaned replacement dairy heifers, breeding bulls (if any), dry cows and milking cows. As well as lactation length, inter-calving interval and calving rate, other important factors are heifer wastage (a combination of pre-weaning calf mortality and losses between weaning and second calving), age at first calving, culling of cows for poor performance and mortalities among the milking herd.

A series of assumptions had to be made on other key variables, namely a lactation length of 300 days, calving rate of 90%, half of the calves born were heifers, 10% of these heifers were sold before calving and the annual culling rate for the milking herd was 35%.

Suggested KPIs for percentage of cows milking in the total dairy herd are:

- 48%; excellent
- 40–47%; acceptable
- 35–39%; below average
- 30–34%; not good.

8.7.3 Average days of lactation for the milking herd

Although the target calving interval is 12 months, this is rarely achieved even in very well-managed herds in temperate developed countries as this requires cows conceiving within 85 days post-calving. This also means that the target 300-day lactation is also rarely achieved. If it is less than this, it is highly likely that the cow dried herself off early because of poor feeding management. It is usually greater than 300 days because the farmer plans to milk her until just 60 days before her calving down again.

Assuming a 300-day lactation length, the average days of lactation for any large milking herd that calves year-round should be 150 days. The greater the average days of lactation, the greater the number of days between calving down and a successful conception, that is, the greater the number of days open. Therefore, the average days of lactation can be a useful measure of the success of the herd's reproductive management.

8.7.4 Wet versus dry milking cows

There are various ways to categorise milking cows on any dairy farm, tropical or temperate. Variables such as daily milk yield (for example, less than 8, 8 to 12, 12 to 16, more than 16 kg/cow/day) and stage of lactation (early, mid, late or non-lactating) are the most common categories used on tropical farms, large or small. There are other ways of categorising cows, which are just as easy and even more informative that are worthy of discussing. This section describes two even simpler categories and what they can tell us about the feeding and herd management on any farm. These are lactation and pregnancy status (Moran 2015).

Adult cows are either lactating (wet) or non-lactating (dry). In the process of their full lactation they are either non-pregnant or pregnant. Pregnancy status is best determined through pregnancy diagnosis (that is an internal examination of the uterus by an experienced technician or veterinarian) but can also be ascertained by 'return to service' (that is whether the cow cycles in ~21 days since she was last inseminated or serviced by a bull).

Each cow would be given one of four possible statuses as follows:

1. Wet and non-pregnant (W/NP) when the cow calves down and before she conceives, usually some time during early lactation.
2. Wet and pregnant (W/P), following conception and up to when the cow is dried off (either naturally or through management).
3. Dry and pregnant (D/P), between drying off and calving down; this determines the minimal length of the dry period.
4. Dry and non-pregnant (D/NP), which should not occur but unfortunately often does.

Using a range of typical scenarios on any tropical dairy farm, the following tables provide data on the minimal length of the dry period and the proportion of cows (including first calf heifers) in each category. The D/NP category is not included in this table because on any well-managed farm, all cows should successfully conceive some time during their lactation. It is assumed that the gestation period is 280 days in length. The calving interval can be as low as 360 days, but is typically more like 400 days on most well-managed farms. The following tables are for year-round calving herds where the data represents the proportion of the herd in any one status on any one day during the year.

These scenarios for herd averages listed in Tables 8.4 and 8.5 are for:

- days from calving to conception; which is assumed to occur on average either at 90, 120 or 150 days into lactation
- lactation length: this is assumed to range from 240 days to 330 days in monthly steps (of 30 days for each month).

Table 8.4. The influence of days from calving to conception and lactation length on the calving interval and on the length of the dry period.

	Calving to conception (days)		
	90	120	150
	Calving interval (days)		
Lactation length (days)	370	400	430
330	40	70	100
300	70	100	130
270	100	130	160
240	130	160	190

It is recommended that cows are dried off at least 60 days before they are due to next calve down to allow the udder to fully recuperate in preparation for the next lactation. Therefore, the dry period in cows conceiving within 90 days of calving and milking for 330 days would be too short, hence they should ideally be dried off after 310 days milking. From Table 8.4, with calving intervals ranging from 370 to 430 days (or 12.3 to 14.3 months), the associated dry periods range from 40 to 190 days. Clearly, the earlier cows conceive after calving and greater proportion of their calving interval that the cows are actually milking for, the greater the income generated through milk production.

Table 8.5. The influence of days from calving to conception and lactation length on the percentage of milking cows in the herd in one of three cow categories, namely wet/non-pregnant (W/NP), wet/pregnant (W/P) or dry/pregnant (D/P).

		Calving to conception (days)		
Lactation length (days)	**Status (% herd)**	**90**	**120**	**150**
330	W/NP	24	30	35
	W/P	65	52	42
	D/P	11	18	23
300	W/NP	24	30	35
	W/P	57	45	35
	D/P	19	25	30
270	W/NP	24	30	35
	W/P	49	37	28
	D/P	27	33	37
240	W/NP	24	30	35
	W/P	41	30	21
	D/P	35	40	44

There are no additional nutrient costs of pregnancy to milking cows if they are non-pregnant or are in their first five months (150 days) of pregnancy. So the occurrence of pregnancy is unlikely to adversely impact of the cow's milk yields and/or feed efficiency until the last few months of pregnancy, which generally occurs during their dry period.

The important numbers in Table 8.5 are then the percentages of cows in the herd that are dry and pregnant because this is the period (once lactation ceases) they must go through to grow the calf *in utero* and when income generation falls to zero. With cows conceiving earlier after calving and milking for longer, these cows can number less than 20% of the herd. However, if conceptions are delayed and the cows are suffering from short lactations, this number can exceed 40%.

In both these cases, namely delayed conception and early drying off, close attention to feeding management is of the utmost importance to address these problems. This is essential first, so cows can minimise the period of their weight loss, to allow the post-calving hormonal cycle to initiate the oestrous cycles that are essential for successful ovulations and consequential conceptions. Second, it is necessary to provide the necessary supplies of feed nutrients within the udder to produce sufficient long-term quantities of milk precursors to minimise any likelihood of nutritionally induced short lactations. This is particularly relevant to many tropical SHD systems as the genetic merit of their cows is rapidly improving through the use of improved dairy genes either through imported semen and/or live animals. Unfortunately, associated with this is an increasing occurrence of repeat breeding as well as short lactations arising from inadequate supplies of feed nutrients, particularly energy and protein.

Dealing with dry/non-pregnant cows

Table 8.5 does not deal with the fourth category in milking herds, namely the D/NP cows. These cows will be non-productive for many months and will cost money every day for at least the next 280 days. If their condition is nutritionally induced, without any change in feeding management, it is likely to be a lot longer than 280 days before they generate any milk income. If the condition is due to animal health issues, then that urgently needs to be diagnosed and treated. A decision will also have to be made as to whether such animals should remain in the herd or be sold as non-productive cull cows.

In summary, dairy cows within any herd of any size can be easily identified as W/NP, W/P, D/P or D/NP to provide an additional tool with which to approach improved feeding and herd management. All it requires is a good set of eyes, a calculator and a notebook. Over time, as we collect additional data, we will be able to provide more definite herd management guidelines, such as threshold percentages of D/P and D/NP (ideally zero) when immediate action is required.

In addition, with further data collection it will be possible to put monetary values on these percentages for the likely financial returns arising from investing in the required improved feeding and herd management.

8.7.5 Persistency of milk yields

The term persistency relates to the ability of each cow to maintain a small steady decline in milk yield as their lactation progresses and is defined as the % monthly decline from peak milk for each month after the peak yield. The higher this number, the faster the rate of decline, hence the less milk produced over a full lactation. In Asia, lactation persistency of less than 8% per month is achievable on very well-managed farms, but more realistic levels are 8 to 12% per month. Assuming peak yields occur during the second month of lactation, it is possible to calculate full lactation milk yields for any cow with a given peak milk yield and persistency. Therefore, over a 300 day lactation:

- cows with a peak milk yield of 15 L/d and 8% persistency produce 3054 L over their full lactation or 10.2 L/d on average
- cows peaking at 20 L/d with an 8% persistency produce 4122 L total milk yield or 13.7 L/d average
- cows peaking at 25 L/d with an 8% persistency produce 5115 L total milk yield or 17.1 L/d on average.

Table 8.6. Full lactation milk yields (and average daily yields) in cows with varying peak milk yields and milking persistency.

Peak milk yield (L/d)	Persistency (%/month)	Monthly milk decline (L/d)	Full lactation yield (L)	Average milk yield (L/d)
15	4	0.6	3702	12.3
	8	1.2	3054	10.2
	12	1.8	2406	8.0
20	4	0.8	4986	16.6
	8	1.6	4122	13.7
	12	2.4	3258	10.9
25	4	1.0	6195	20.7
	8	2.0	5115	17.1
	12	3.0	4035	13.5
30	4	1.2	7479	24.9
	8	2.4	6183	20.6
	12	3.6	4887	16.3
35	4	1.4	8688	29.0
	8	2.8	7176	23.9
	12	4.2	5664	18.9
40	4	1.6	9897	33.0
	8	3.2	8169	27.2
	12	4.8	6441	21.5

Table 8.6 presents the full range of milk production data, for cows with peak milk yields varying from 15 to 40 L/cow/d and with monthly milk persistency varying from 4 to 12%/month. Full lactation yields then range from as low as 2400, as expected in traditionally managed lowland smallholder farms, to as high as 9900 L/cow, as achievable in well-managed dairy feedlots in the Asian highlands. Corresponding average milk yields range from 8 to 33 L/cow/d. Clearly feeding and herd management should be directed towards ensuring a 'flat lactation curve' throughout the entire lactation.

A very high rate of decline, indicating a rapid drop off in milk yield post peak, is often indicative of poor feeding management during early and mid lactation which often, particularly in high quality dairy cows, leads to rapid weight losses and delays in the first post-calving oestrus, thus resulting in reduced herd fertility. Therefore, for these cows in particular, feeding management must be directed towards supplying adequate nutrients, particular energy, in early lactation to achieve high peak yields, and in mid lactation to maintain milk yields with low persistency values.

The reason why persistency is an important measure to monitor is that when high genetic merit cows are underfed, they have been selected to utilise their body reserves to provide the nutrients in the mammary tissue to maintain milk yields. In other words, they have been bred to preferentially partition dietary nutrients from their fat reserves (mainly abdominal) to the udder. In so doing, they must lose bodyweight and this reduces the hormonal balance in the body necessary to allow ovulation and so allow the cow to show oestrus. This is called lactation anoestrus. Therefore, such cows will delay oestrus, hence have more days open. Such cows then require preferential treatment to bring them back into oestrus and need to be rapidly identified. Milk persistency can then be used to locate such cows that are more likely to have poor reproductive performance.

8.8 Milking management

The key to producing high quality milk is good hygiene and its rapid cooling following milking. Hot water is essential in any milking shed to ensure all milking equipment can be cleaned and sanitised.

Milking machines

As it is assumed that 500 cows are too many to milk by hand, all sheds will be using milking machines. The principles of maintaining milking machines are the same whether they are mini bucket milkers with one or two clusters or larger machines in a milking shed with several milk clusters. Pulsators should run at 50 to 60 pulsations/min while vacuum pumps should run at 40 to 50 kPa. All milking equipment must be routinely serviced.

One of the most common causes of mastitis outbreaks is inappropriate milking machine function. The need for routine milking machine maintenance cannot be over-stressed.

Rubber ware

From the functional aspect of a milking machine the most important piece of equipment on the machine is the liner or inflation. The inflations are the only part of the machine that comes in contact with the cow. From the day they are fitted to the milking machine they begin to deteriorate and lose their flexibility. A good rule of thumb is to replace the inflations after 2500 milkings, using the following simple formula:

$$\text{Replacement age (days)} = \frac{2500 \times \text{number of claws}}{\text{herd size x milkings/day}}$$

Apart from functional aspects of the inflation, the other concerns are the milk quality problems caused by deteriorated rubber ware. Long milk rubbers should also be replaced regularly (usually every 9–12 months).

Milking routine

Operators must be well trained and understand the need for routine and effective milking routine and management. They should wear disposable gloves and preparation should include cleaning if the teats are dirty. This is best managed using single wipes for each cow. This can follow pre-dipping, using a separate section of the wipe to clean each teat, or use them dry on each teat. Prior to attaching the milk clusters, one to two squirts of milk should be stripped out of each teat onto the floor, or a strip cup for closer examination. The operator must also be aware of any swelling and heat in the udder. Any sign of mastitis needs to be recorded and reported and possibly treated, according to predetermined mastitis management program SOPs.

This preparation will also provide the necessary pre-stimulation for letdown to occur. Teat wipes can be new paper towels or re-usable cloths that are thoroughly washed and dried completely following each milking.

If teats are not cleaned, they need to be gently massaged by hand, stripped and then allowed to rest for at least 30 s before clusters are placed on teats, to allow for milk letdown to occur.

Cups need to be removed when milk flow has almost ceased. Massaging the last of the milk out of the udder is not recommended, as this may create vacuum in the udder and reverse airflow into the teat and udder after cluster removal. Since over-milking will cause teat-end damage and can lead to mastitis, the small amount of milk remaining is not an issue.

Teats need to be effectively dipped or sprayed with a recommended and freshly prepared post-milking teat dip. Cows then need to walk on clean laneways and kept standing for 30 min to one hour.

If teats and udders are excessively dirty, running water may be needed to clean them properly. However, the teats must be dried, with a new paper towel, before 'cups-on'. In this situation, housing and bedding, as well as laneway issues need to be addressed in order to ensure clean and dry teats and udders at all times. It must be stressed that poor environmental conditions will ultimately lead to mastitis. Furthermore, fly control is also important.