19

Overcoming environmental constraints to cow performance

This chapter:

Explains some of the important non-nutritional factors adversely affecting cow performance: genetics, heat stress, sanitation, animal health and the management of imported livestock.

The main points in this chapter:

- there is continuing discussion about the importance of genotype × environment interactions when selecting dairy genotypes for small holder dairy systems
- there are both direct and indirect effects of the hot and humid environment on cow performance, in that cows are routinely subjected to heat stress (direct effects) and forage quality is adversely affected by such climates (indirect)
- heat stress can be alleviated through cow shed design as well as management procedures to improve heat dissipation
- dairy effluent is an asset (fertiliser) as well as a major polluter
- small holder farms with tethered cows create many and varied health issues, such as shed hygiene and feet and leg problems
- when purchasing dairy stock from other countries, importers should recognise their specific requirements, which differ from those of local stock.

As the level of feeding in milking cows improves, so too does their susceptibility to other environmental constraints such as climatic stress, disease, pollution and poor herd management. For example, better fed and higher yielding cows are more adversely affected by heat stress, because of their higher internal heat production. This chapter may seem out of place in a manual on feeding, but since maintaining high nutrient intake becomes more difficult as it increases, environment has a major influence on the overall management of the high yielding herd.

19.1 Problems with exotic genotypes

The decision makers of most, if not all, South-East Asian countries place high credence on improving the genetic quality of their national herds. This has led to an influx of dairy stock from temperate areas, where they have been selected for many generations. According to McDowell (1994), over 25 countries in the 'low latitudes' (namely equatorial and tropical areas) are developing local milk industries based on imported dairy cattle, mainly Friesians from the temperate developed dairy industries in Europe, North America and Australasia. During the 20 years to 1995, 5 million Friesians have been exchanged in international trade, with half moved from temperate climate countries to those in the warm climate zones. All countries in Latin America have nucleus herds based on Friesians, as do 70% of the Asian and 66% of the African countries. The major exception has been India, which has based its genetic improvement program on indigenous dairy cattle and buffalo.

The importing countries are also being encouraged, often through financial subsidies, to use semen from progeny tested sires from countries of origin of these cattle, thus continuing the program of genetic upgrading of the temperate dairy stock. But with few exceptions, their low milk yields (2500 to 5000 L/lactation), high ages at first calving (30+ months) and long calving intervals (430 to 485 days) may not even support bank rates of credit for their purchase (McDowell 1994). Modern Friesians are genetically capable of producing their first calf at two years of age, then one every 12 months, yielding 8000 L milk over 300 days and milking for five lactations.

Ibrahim *et al.* (1992) reviewed 10 years of dairy development in Indonesia (East Java), concluding that increases had been mainly through imported cattle, but production gains were only at one-third of their genetic potential. The main reasons they listed would be relevant to many South-East Asian countries, being:

- lack of sufficient high quality feed
- poor adaptability of imported stock to local conditions
- poor housing and management
- too much attention of cooperatives to marketing and insufficient extension on cow problems
- failure to repay dairy credit in view of low productivity and poor milk price.

19.1.1 Genotype by environment interactions

Like all genetic improvement programs, be they livestock, cereal grains or fruit trees, the use of exotic gene stock needs to be accompanied with modifications to the environment. McDowell (1994) contends that this is not happening with dairy cattle because there still prevails the perception that Friesians, Jerseys or other improved dairy breeds can perform well on diets based on low to moderate digestible tropical grasses, in a foreign environment with temperature, disease, pollution and other production constraints.

Small holder dairying utilises a wide range of dairy stock in the humid tropics. These four types range from:

1 local, unimproved cattle with little breeding for milk production
2 crosses between local cattle and Zebu dairy breeds

3 crosses between local cattle and temperate dairy breeds
4 purebred temperate dairy breeds.

There is continuing discussion over the 'ideal' genotype for small holder dairying in the humid tropics. One rational approach is to consider the Genotype (G) by Environment interaction (ie G × E). Briefly, the relative performance of two genotypes depends on environment under which they are managed. When upgrading a national dairy industry from Type 1 above, is it better to base the industry on Types 2 or 3 and eventually on Type 4? More importantly, at what level of feeding and general herd management should the industry move from Type 3 to Type 4 cows?

The evolution of the dairy industry in the wet tropics of Central America is a good example of understanding how the breed must fit the system. There, the industry is now based on dual purpose cattle, rather than as it was 20 years ago, on traditional specialist dairy breeds such as Friesians. Cows are milked with the calf at foot and weaning generally coincides with the end of lactation. Income is generated from milk plus quality meat from yearling stock, rather than just the poor quality meat from cull cows as is usual in most dairy systems. This system has evolved because the dairy cows, being Zebu type, require calf presence to stimulate milk let down, they tend to dry off prematurely when daily calf contact ceases, and because milk substitutes and high quality calf concentrates are either not available or are prohibitively expensive.

No single tropical dairy type can be defined as the 'best'. The 'best' type will vary from local genotypes through to high grade Friesians. Unless heat stress is controlled, Vercoe (1999) believes that the very high yielding temperate breeds will always be less efficient than locally evolved ones. Such animals would be developed through crossbreeding local and exotic breeds then selecting within these populations for high milk yields. Similarly, it is unlikely that local breeds as purebreds will be the most profitable in all but the poorest of situations, where feed is inadequate, parasites and diseases are uncontrolled and levels of production barely fulfil household needs.

The genotype and its management must then be matched to:

- climatic conditions that exist
- available nutrition, whether home grown or supplemented with purchased feeds
- degree of challenge from parasites and diseases
- level of management skills
- availability and costs of labour to feed, milk and market the product, and its priority with other household demands
- availability of finance
- availability and access to profitable markets.

19.1.2 Specially bred tropical dairy genotypes

The ideal tropical dairy genotype is a small animal that yields high levels of milk and/or milk solids, annually produces a live calf (preferably a heifer) under simple small holder production systems based on tropical forages and with minimal environmental manipulation and low exposure to disease (Shamsuddin *et al*. 2003). Unfortunately such a genotype does not exist because high milk yields require high intakes of quality forages together with high internal heat production, hence management to alleviate heat stress.

Over the last 50 years, there have been various programs to develop tropically adapted dairy genotypes. These include the Jamaica Hope (80% Jersey, 15% Sahiwal, 5% Friesian) in the Caribbean and the Australian Milking Zebu and Australian Friesian Sahiwal in Australia. The objective of such breeding programs was to develop a stabilised genotype with the combined attributes of tropical adaptation and superior milk and reproductive performance. Although such stock would not exhibit the hybrid vigour of crossbreds, their progeny would be less variable in their physical and productive traits.

The Australian Milking Zebu program, which ceased in the 1970s, was based on Jerseys and Red Sindhi breeds, and produced a relatively small cow with low yields of high solids milk. Such a genotype would be ideal for many small holder industries, such as in Indonesia, where most of the milk is destined for industrial processing (hence the benefits of high solids content) and the feeding management is better suited to small cows with low maintenance requirements. However, when recently asked about the suitability of such a genotype, industry leaders in Indonesia considered the Australian Milking Zebu and Jersey to be less suitable because of the Friesian's better dairy beef sale value for bull calves or cull cows.

The more successful Australian Friesian Sahiwal program, which ceased in the 1990s, was based on Friesians and Sahiwal breeds. Such animals are currently in great demand throughout South-East Asia because of their performance in small holder dairy systems. Their Sahiwal ancestry provided the desired tropical adaptation to compliment the dairy performance of the Friesian. Preliminary discussions are now underway to resurrect this breeding program. Such a program would require a good database on the genetic variability of local Friesian populations, a shortfall in many South-East Asian countries where robust herd recording, and performance and progeny testing programs, are often lacking.

19.1.3 Problems of confinement

Compared to grazing, confinement creates specific problems, such as:

- restricting opportunity to seek comfort, for example, if only provided with cement floors
- creating problems of high humidity, which can be more detrimental than high temperature
- limiting opportunity for exercise, hence the need for routine hoof trimming
- increasing exposure to infectious diseases
- other health issues, such as mastitis and uterine infections when hygiene is poor during milking and calving
- creating problems of heat detection for artificial insemination
- requiring greater efforts into sanitation
- magnifying problems of social dominance
- increasing capital investment.

This chapter will concentrate on several of these issues, such as heat stress, sanitation, management to minimise animal health problems.

19.2 Alleviating heat stress

19.2.1 Direct effects on cow performance

The comfort zone for milking Friesian cows is 6ºC to 18ºC. Within this range, there are no measurable fluctuations in their physiological processes while the energy input to output shows good biological efficiency, in that all body processes will be functioning in their expected ranges. Between –5ºC and +5ºC, appetite will be stimulated while at the upper level, above 27ºC, appetite is depressed and both biological and economic efficiencies decline. Above 24ºC, Dry Matter (DM) intake decreases by about 3% for every rise of 1.2ºC (McDowell 1994). The extent of the effects of temperature on appetite depend on:

- type and quality of forage – intakes of high fibre forages are more depressed at high temperatures
- type and quality of concentrates
- relative humidity – high humidity exaggerates the effect of high temperature
- stage of lactation – cows in early lactation are more susceptible to heat stress
- milk yield – high yielding cows are more susceptible to heat stress
- actual appetite.

Consideration should also be given to the type of protein source in the diet because depressed appetite and higher nitrogen excretion in the urine can lead to induced protein deficiencies. Although they recorded no difference in milk yield, Terada and Shoiya (2004) found that diets higher in Rumen Degradable Protein content reduced nitrogen loss in the manure and also body temperatures, respiration rates and the number of days to first oestrus in high yielding (<25 L/cow per day) Friesians subjected to heat stress.

When planning feeding programs, consideration should be given to the number of hours each day when temperatures exceed 27ºC and relative humidity exceeds 80%; feed intakes will decline once temperatures exceed 27ºC or higher for six hours. Furthermore, high body temperatures reduce the efficiency of rumen digestion and increase body maintenance requirements, further increasing the energy deficit. The net effect on feed intake depends on the number of hours each day below 20ºC, which allows cows to cool and hence restore their heat balance.

The greater susceptibility of cows in early lactation to continuing levels of heat stress is clearly apparent from Table 19.1. In addition, heat stress adversely affects reproductive performance in three ways:

1 Acute stress can lead to embryo reabsorption while chronic stress upsets normal cyclic status, through hormonal changes, particularly if cows are exposed to six hours or more to temperatures above 27ºC.
2 In late pregnancy, reduced foetal growth can also result from heat stress, leading to increased calf mortalities.
3 The intensity of expression of oestrus is depressed, in that oestrus periods are shorter (eg 12 v 17 hr) and although cows do cycle during hot periods, the percentage of those actually observed can be as low as 35% to 40%. This can be partly overcome by more frequent observations, such as every 6 hr rather than 12 hr.

Table 19.1 Effect of per cent days when temperature exceeds 27ºC for six hours or more on feed efficiency of Friesian cows

Feed efficiency is measured in milk yield/unit energy intake and expressed as proportion of that for cows in early lactation in the least stressful environment. (Source: McDowell 1994)

	Percentage (%) days >27ºC for 6 hr or more		
Stage of lactation (days)	0–20	21–40	40–87
0–100	1.00	0.87	0.73
101–200	0.96	0.91	0.88
201–300	1.02	0.91	0.85

The Temperature Humidity Index

The best single descriptor of heat stress is the Temperature Humidity Index (THI), as this combines temperature and relative humidity into a single comfort index. The higher the index, the greater the discomfort, and this occurs at lower temperatures for higher humidities (see Appendix 1).

For Friesians producing 20 L/d, a Temperature Humidity Index above 78 leads to a decline in milk yield. A Temperature Humidity Index of 78 occurs at 29°C with 50% humidity or at 27°C with 80% humidity. There is also a decline in milk composition (milk fat and milk protein contents) but this occurs at 1°C to 2°C higher than corresponding break points for milk yield (Davison *et al.* 1996). With regards reproduction, this declines before milk yield, namely at Temperature Humidity Index of 72, equivalent to 25°C plus 50% humidity or 23°C plus 80% humidity. The duration of oestrus drops from more than 10 hr to less than 8 hr. When planning strategies to minimise heat stress, it is then important to give priority to non-pregnant cows, usually in early lactation.

Symptoms of heat stress

There are many symptoms of heat stress, with those ones more relevant to cows in sheds shown below in italics. The initial signs are behavioural while the more severe ones are physiological, thus requiring immediate attention, to reduce their adverse effects on cow performance. In order of increasing severity, they are:

- body aligned with direction of solar radiation
- seeking shade
- *refusal to lie down*
- *reduced feed intake and/or eating smaller amounts more often*
- crowding over water trough
- body splashing
- *agitation and restlessness*
- *reduced or halted rumination*
- grouping to seek shade from other animals
- *open mouthed and laboured breathing*
- *excessive salivation*
- *inability to move*
- *collapse, convulsion and coma*
- *physiological failure and death.*

19.2.2 Indirect effects on cow performance

The greatest indirect effect of temperature is on feed quality and to a lesser extent seasonal changes in forage yield. Tropically adapted grasses have developed different pathways of photosynthesis to temperate species, allowing them to be classified as either C_3 (temperate) or C_4 (tropical). The C_4 grasses are more efficient at converting sun energy to forage dry matter, but at the same stage of plant maturity, they are usually of lower nutritive value, as shown below:

Table 19.2 Effect of plant physiology (C_3 or C_4) and age on digestibility and metabolisable energy content of forage grasses

Growth stage (days)	Digestibility (%)	ME (MJ/kg DM)
Young (45 d)		
C_3	69	9.7
C_4	58	7.6
Bloom		
C_3	64	8.8
C_4	45	5.6
Mature (60 d)		
C_3	54	7.1
C_4	38	4.3

Furthermore, increasing temperatures promote deposition of cell walls, reducing nutritive value, more so in C_4 than C_3 grasses.

Although not necessarily the direct result of higher temperatures, tropical soils are highly weathered, often with low pH (<5.3) and low in available soil nutrients. This can lead to low mineral contents in tropical forages, particularly phosphorus. Tropical environments are also more conducive to internal and external parasites.

Reduced forage quality and imbalances in feed nutrients invariably reduce milk yields and increase dry periods, due to delayed oestrus. Lengthy dry periods, exceeding 120 days, can produce overfat cows, increasing the likelihood of metabolic diseases following calving. In warm climates, calves will use 15% more energy to maintain heat balance than will their peers in temperate areas. The high humidity levels in the tropics, in conjunction with lower levels of calf care can also lead to higher incidence of respiratory problems, with long term effects on cow performance.

In practical terms, the stresses imposed by the direct effects of high temperatures are more apparent (eg changing behaviour) and can be more easily addressed. However, the indirect effects are less visible and may not be apparent until they become more serious with long-term consequences.

19.2.3 Designing cattle housing to minimise heat stress

Housing reduces heat load during mid day, where outside temperatures exceed 30°C, but the number of hours during the day when they exceed 27°C is the same both under a shelter and outside.

For cows producing 20 to 30 L milk/d and fed under corrugated iron during daylight with a sprinkler system, milk yield will not decline until the Temperature Humidity Index reaches 83 (ie at 33°C and 50% humidity or 30°C and 80% humidity).

Shed design

Assuming the sides of the shed are open to allow maximum ventilation, greater use should be made of the principles of air movement when designing the roof. Because hot air rises, and a herd of milking cows in a shed produces considerable heat, there should be an opening along the top of the roof, with a cap over it to restrict rain entering the shed. The roof slope should be greater than for feed sheds, namely 3 to 4° per 2.3 m, with the opening at least 50 cm wide, and the full length of the shed (McDowell 1994). Davison *et al.* (1996) recommend a roof slope of 33° (4 in 12), with a vent at the top of 30 cm plus 50 mm per 3 m of width for sheds with more than 6 m wide. An opening larger than 70 cm does not improve air flow. The lowest point of the roof should be 3 m from the ground. The steeper roof pitch increases air flow across and above the roof, thus creating negative pressure over the opening. This hastens the flow of air out the top as well as creating turbulence of air movement around the cows. If farmers are concerned about rain entering the shed through the vent, a gutter system can be installed below the ridge opening while the concrete floor can be sloped away from the feeding area.

A north–south orientation is preferable to allow the sun to dry underneath both sides of the shed. An east–west orientation is not recommended as the southern side will have less opportunity to dry out. Trees should be planted on the western side of the shed to reduce solar radiation. Grass, rather than cement, around the shed is also effective. Shade cloth, that blocks 90% of the light, can also provide protection provided it does not interfere with ventilation within the shed. I have seen mosquito netting in some regions, but such a decision would depend on recommendations of local veterinarians as to the potential animal health dangers of mosquito infestations. Eaves that extend one-third the side height will provide good sun protection.

An effective insulation of a cow shed, using egg cartons (Banbeung, Thailand).

The shed should be situated so that wind breezes are not blocked by any obstacles or other buildings. Ideally the shed should be on the highest ground possible, which will also be good for drainage of effluent, with other buildings located down wind on the site. There should be a minimum of four times the height of the nearest wind barrier as a horizontal separation. The ideal orientation, from a ventilation point of view, would allow the prevailing winds to hit the shed perpendicular to the side. This allows the wind to travel the shortest distance before exiting the shed, to improve the rate of air exchange and provide the cows with fresh air. The longer the shed, the more important is this perpendicular orientation to the prevailing winds. Other factors to consider are exposure of the outside stalls to sunshine, future expansion plans, cow flow, traffic flow and manure flow.

White-painted buildings reflect the solar radiation better than dark-painted buildings. Reflecting roof materials such as galvanised or aluminium are good long term investments. Insulation under the roof can reduce the heat load. Spraying water on the roof may only be effective in reducing roof and shed temperatures in areas with low humidity. One enterprising farmer in Thailand placed a layer of egg cartons underneath the roof as insulation against intense solar radiation (see picture on page 226).

Cooling fans

Fans can be arranged in many ways. A 0.5 horse power, 0.91 m diameter fan rated at 5 to 6 m^3/min will blow a distance of 9 m, while a 1.0 horse power, 1.21 m diameter fan rated at 9 to 10 m^3/min will blow a distance of 12 m. The direction of the fans should be with the prevailing wind. In wide sheds, the side-by-side spacing width of 0.9 m fans should be about 6 m, whereas 1.2 m diameter fans should be spaced 9 m apart. They should be positioned about 2 to 2.2 m above the floor. Fans should be tilted so they blow down to the floor directly under the next fan (about 30^o from the vertical).

Exhaust fans, that do not require external power, may be worth considering to encourage greater heat removal through the roof. Household fans on stands may be used to improve heat loss from the higher yielding cows.

Sprinklers

Evaporative cooling is an efficient way of cooling cows, provided it is effective. In hot humid areas, sprinklers should always be accompanied by some form of ventilation.

Sprinklers have the disadvantage of increasing humidity and making the floor wet. Many studies show although they are beneficial in the short term, without forced ventilation, but they do not greatly improve feed intake, milk yield or expression of oestrus over a full 24 hr period. Their effectiveness depends on the humidity as the drier the air, the greater the decrease in temperature.

Sprinklers need to be suspended at least 2.3 m from the ground above the feed troughs with the water directed to the back of cows. The droplet size should be medium to large, depending on the humidity. It is important to install a filter at the beginning of the waterline and the sprinkler nozzles should be easily removed for cleaning. The nozzles should be directional, if possible, so that for major prevailing wind shifts, they can be adjusted to reduce wetting of feed.

Applying water to cows every five minutes reduces heat stress more than every 10 or 15 min. Ideally, cows should be sprinkled for 1 to 3 min, applying 1 to 2 mm of water per 15 min cycle. Using a timer system makes for easier management. The pipe size depends on the length and area of the shed to be sprinkled, the number of sprinklers and the flow rate. Use 32 mm diameter pipe for up to 30 m length or 51 mm diameter pipe for 60 to 150 m length. Nozzles should be spaced at twice the radius of their throw (eg every 2.4 m for nozzles with a 1.2 m radius).

Cows can be hosed down at the same time as their udders and teats are cleaned in preparation for milking, but this should occur at least 30 min prior to milk harvesting to minimise such wash down water contaminating the milk.

19.2.4 Management practices to minimise heat stress

Decisions based on respiration rates

Observing the behaviour of cows is important in deciding when to modify management. If respiration rates reach 70 breaths per minute, milk yield and reproduction may be compromised; this corresponds to 39ºC body temperature, in contrast to a normal body temperature of 38.5ºC. Higher yielding cows have faster respiration rates, because of the extra body heat production associated with higher feed intakes and milk yields .For such animals, respiration rates above 60/min are indicative of heat stress. Certainly, when they exceed 100/min, cooling strategies should be introduced. Improvements in milk yields of up to 3 to 5 L/d are possible through effective cooling strategies.

Respiration rates are easy for farmers to monitor. Ensure the cow is standing or lying in a relaxed state and preferably cannot see the farmer. To improve accuracy, the farmer could move his hands in time with abdominal movements until they are at a steady rate. Using a watch, he should count the abdominal movements for 10 seconds, repeating the exercise to ensure the count is consistent. Multiplying this by 6 will give the respiration rate in breaths per minute.

Monitoring respiration rates at various times of the day is a useful tool in assessing the suitability of sheds for milking cows. If rate exceed say 60/min in the morning, prior to the shed heating up, the cows would probably benefit from simple modifications in their environmental management. It is unlikely that major modifications in shed design could be justified, such as increasing roof height or pitch or shed height at the side, although serious consideration should be given to constructing roof vents. If minor improvements cannot be made in the shed's natural ventilation, such as removing obstructions to the prevailing breeze, fans and/or sprinklers should be installed.

One enterprising farmer in Vietnam constructed a small shelter away from the cow shed, which maximised natural ventilation through a high roof and its location, making best use of prevailing wind. Whenever he noted cows with high respiration rates, he hosed them down then moved them to the small shed to alleviate their heat stress.

The easiest cooling method is to hose down the cow for several minutes. This should reduce respiration rates to 60/min. If the cow was severely stressed prior to cooling, with open mouthed and laboured breathing and excessive salivation, after being hosed down, she should soon return to the feed trough and start eating.

Cooling a cow with a hose. Note the very low roof which would restrict air movement hence heat dissipation from cows in this shed. (Binh Duong province, Vietnam).

Allowing cows outside during the evening

Management systems can reduce heat stress by providing access outside the shed during the cooler afternoon and evenings, say after 5 or 6 pm. This will promote more effective conductive heat loss than inside, hence restore body comfort. This lounging area should:

- be located in a well-ventilated area
- be well drained
- have a dirt or gravel surface
- provide at least 5 to 10 m^2/cow
- incorporate water troughs
- incorporate troughs for feeding forages.

Moving cows outside following the afternoon milking could be combined with a change in routine milking management on small holder dairies, namely having a specific milking area within the shed, rather than milking cows where they are tethered. Milking parlours are easier to keep clean than the entire shed and the facilities can be sterilised periodically to improve milking hygiene.

It is difficult to monitor signs of oestrus in tethered cows. Providing cows with the opportunity to mingle in outside yards will allow them to seek out any cows on heat.

Feeding management

The digestion of fibre produces more heat in the rumen than the digestion of other carbohydrates. Therefore, offering most of the daily forages during the cooler periods of the evening will reduce internal heat production, particularly if the forages are high in fibre, which tropical forages usually are. Rations high in Rumen Degradable Protein can also depress appetite during periods of heat stress. Cows consume about two-thirds of their feed during the cooler evening and night. Feeding smaller amounts more frequently will reduce the likelihood of forages drying out and losing its palatability. The cooler the drinking water the better for both intake and temperature balance in the body.

When given continual access to feed, cows actively seek it from 5 to 9 am and again from 5 to 7 pm. Milkings should be finished prior to 6 am and 6 pm. Cows prefer feeding and watering following milking, after which they should be offered a dry surface on which to rest, preferably dirt. It is important that cows stand for at least 30 min after milking so the teat end can close to protect the teat canal from bacterial invasion.

Heat stress can lead to higher incidences of lactic acidosis (see Chapter 13). Depressed feed intakes will first, reduce saliva production which buffers the rumen against rapid changes in pH, and second, reduce rumen contractions, hence movement of digesta out of the rumen. Furthermore, rapid respiration rates for lengthy periods can reduce the concentration of sodium bicarbonate in the saliva, reducing its buffering capacity even further. In addition, cows may preferentially select concentrates and reject forages, predisposing them to acidosis.

Reduced forage intakes can decrease milk fat contents, while milk protein (or solids-not-fat) contents may fall due to lower dietary energy intakes. When the immune system of heat stressed cows is under greater strain, they are less able to cope with subclinical mastitis, which becomes apparent in higher levels of somatic cells in the milk. Not only would heat stress reduce milk yield, but its lower milk solids and higher somatic cell counts would reduce milk returns even further through lower unit returns for the milk.

Feed manger height is best when cows are eating with their heads down, to minimise wastage and obtain highest intakes. Cows produce 17% more saliva in this position compared to feeding with their head in a horizontal or raised position.

19.3 Sanitation and effluent management

Dairy farm effluent is both a liability and an asset to the small holder farmer. It is a liability so far as contaminating feeds, encouraging flies, and animal health issues, whereas its role in fertilising forages is an asset. Unfortunately, its full potential is not realised unless all the nutrients contained in the urine can be returned to the pastures. The nitrogen in urine is easily lost through volatilisation, unless it is stored and recycled to the pastures mixed with water.

19.3.1 Effluent as a liability

The management of animal manure represents a major health hazard on small holder farms, with the problem increasing with herd size, unless specific facilities are constructed. The problem is associated with several issues:

- quantity and quality of faeces and urine produced
- adequacy and frequency of removal
- storage in proximity to shed
- labour availability
- methods of storage and disposal
- value and use of manure
- community concern about pollution (smell as well as contamination of ground water and water courses).

The human health hazards are becoming more serious than previously realised, due to inadequate supervisory and sanitary measures. For example, in Thailand, a survey noted wastewater from small holder dairy farms constituted a considerable risk to public health because of its very high contents of inorganic pollutants and the presence of coliform organisms (Chantalakhana *et al.* 1998). Furthermore, there was considerable contamination of ground water supplies in nearby towns via waste water from local farms as well leaching from stored manure.

Not only is effluent management an environmental constraint to small holder dairying because of its potentially adverse influence on cow performance and cost of forage production, but also equally important, it can alter the livelihood of farmers themselves through community legislation limiting locations of farms. This can be particularly important for dairy farmers situated close to large towns and cities. In developed countries, considerable effort is spent in ensuring that farming activities are seen as ‘clean and green’ and this concept will no doubt extend into the humid tropics.

19.3.2 Effluent disposal systems

The floor should be made from concrete or easily washable material. It should be designed for efficient drainage with a good slope with wide channels for easy urine and faeces removal. A manure pit should be dug, large enough to hold the shed’s manure produced over two or three days. A channel should be dug leading from the walking area to the pit and lined with concrete. The pit should be covered with a plastic sheet or banana leaves to reduce the sunlight, as this volatilises the nitrogen in the manure, reducing its value as a fertiliser. A fence around the pit will minimise risks to children and wandering stock.

As much urine as possible should be collected from the shed. It is advisable to use minimum water to initially wash out the manure drains, then direct the main washings from the floor into another pit or direct out to the forage producing area. An alternative effluent system is to all manure and shed washings to flow into the one pit which is equipped with a manure pump to direct the effluent to the forage producing area, along gutters between the rows of plants.

19.3.3 Effluent as an asset

Cows, on average, produce daily: 46 kg of manure, from 32 kg faeces and 14 kg urine, containing 0.15 kg nitrogen, 0.04 kg phosphorus and 0.08 kg potassium (Choi *et al.* 2004). Its use when recycled on the farm as fertiliser for forage production is discussed in Chapter 8.

19.4 Management problems specific to small holder farms

19.4.1 Animal and human health

High standards of sanitation are required at all times to prevent rapid spread of infectious diseases in both young stock and milking cows. The most effective way of destroying disease carrying microorganisms is cleaning and disinfecting (sterilising or sanitising). However, the latter has little effect unless the surface is first cleaned. The best cleaner and disinfectant depends on the type of surface.

Government veterinary services must maintain surveillance of infectious or notifiable diseases, such as rinderpest, foot and mouth disease, and contagious pneumonia, through vaccination and quarantine measures. However, as farms become more intensively managed, non-infectious diseases become more important role in limiting cow performance. These could be called disease-causing risk factors such as undernutrition, poor hygiene and other management factors affecting herd productivity.

Farmers are only interested in herd health programs when the link with production is clear, such as declining milk yields, increasing mortality and poor reproduction. Mastitis, for example, is hard to manage because the subclinical form is very prevalent, difficult to detect and causes higher milk losses per affected cow. It is often difficult to incorporate economic parameters in such programs because of the few stock, and hence the influential impact of the performance of each animal.

There are many diseases that can be transferred from intensively managed livestock to humans. These include *Salmonella* (and other calf scour-causing microorganisms), ringworm, mange (and other skin diseases) and *Leptospirosis* and *tuberculosis*. Children are particularly susceptible because of their affinity to young calves, and their poor understanding of human hygiene. Another potential hazard for young children are veterinary drugs and chemicals used for cleaning or sanitation. These should be stored in a secure place.

19.4.2 Feet and leg problems

Feet problems

These can be caused the environment (continuous wet floors, uneven or broken cement), poor sanitation, infectious organisms or nutritional imbalances. With tethered cows, annual trimming can extend herd life by at least one year. There are recommended dimensions for hoof claws and many confined herds have cows outside these recommendations, which are:

- toe angle, 40° to 50°
- toe length, 1st lactation 60 to 70 mm; later lactations, 60 to 80 mm
- diagonal length from top of heel to end of toe, 140 to 150 mm.

Overgrowing will cause the toe angle to decline and foot length to increase, placing more weight on the heels, thus creating discomfort and walking difficulty. The rear feet appear to be more subject to disorders. High levels of concentrate feeding can lead to a condition called laminitis, which causes softening of the tissue between the claws of the feet. Trauma injuries can occur on uneven concrete floors, leading to swollen hocks, knees or even hips.

Bruised soles

Inside the hard, outer layer of the hoof wall and sole, there is a sensitive layer rich in blood vessels and nerves. If a cow stands on a stone, or some other small hard object, its sole bends upwards over the stone, severely squeezing the sensitive layer. This can cause bleeding within the claw, and subsequently pressure, pain and lameness.

Bruising is identified in a well-cleaned sole as pink or dark red flecks. Very soft feet, due to moist or wet conditions, are more prone to bruising. If the sole is thin due to excessive wear, it offers less protection to such damage. Such wear can result from standing on very rough concrete floors or animals being bullied by dominant animals or even excessive turning on floors when on heat.

Bruising will repair with time but rest is important. Particularly severe bruising may need some form of relief from the pressure of body weight and walking. If bruising is largely confined to one claw, glue-on plastic or leather lace-up shoes can be fitted. Preventative measures include ensuring floors are not too abrasive, with all stones and broken pieces of concrete removed. Hoof trimming will also assist. Foot baths containing formalin (for hardening hooves) or sprays of zinc sulfate solution (for treating sore feet) are also useful.

Providing cows with soft bedding, such as a dirt lounging area or rubber mats improves cow comfort as well as reduces feet and leg problems. Other factors influencing sore feet resulting from acidosis are discussed in Chapter 13.

Assessing cow lameness

Lameness is an increasing problem in both grazing and housed cows, with economic implications. Locomotion scoring from 1 to 5 (for increasing lameness) is a new tool (Sprechter *et al.* 1997), which provides a quick measure of the cow's ability to walk normally (Table 19.3). Observations should be made of cows standing and walking (gait), with emphasis on their back posture. Observations should be made on a flat surface that provides good footing for cows.

Locomotion scores of individual cows can be used to select cows for hoof examination before they become clinically lame. Those with scores of 2 and 3 are considered subclinically lame and their hoofs should be examined and trimmed to prevent more serious problems. Scores of 4 and 5 represent those cows clinically lame. The higher the lameness score, the greater the reduction in feed intake and milk yield and the poorer the body condition. For example, a score of 4 can reduce dry matter intakes by 7% and milk yields by 17%, while a score of 5 can reduce dry matter intakes by 16% and milk yields by 36%.

Table 19.3 Locomotion score guide based on observations of back posture and behaviour when walking (Source: Sprechter *et al.* 1997)

Score	Clinical description	Back posture	Assessment
1	Normal	Flat	Cow stands and walks with a level back. Gait is normal.
2	Mildly lame	Flat or arch	Cow stands with level back, but arches when walks. Gait is slightly abnormal
3	Moderately lame	Arch	Stands and walks with arched back. Short strides with one or more legs.
4	Lame	Arch	Arched back is always evident and gait is one deliberate step at a time. Cow favours one or more legs/feet but can still bear some weight on them.
5	Severely lame	3-legged	Cow demonstrates an inability or extreme reluctance to bear weight on one or more limbs/feet.

19.5 Importing cows and heifers from other countries

Most countries with small holder dairy industries have development programs involving increasing cow numbers and genetic quality through importing dairy stock, usually Friesians.

The major oversight by both the importers, whether private investors or government organisations, and the farmers for whom these stock are destined, is not ‘preparing the environment’ for the imported stock. The greatest shortfalls are:

- lack of knowledge of quality of local feedstuffs, particularly forages
- lack of understanding of their nutrient requirements for acceptable performance, to reduce stress
- low skills of local labour to handle high level of technology in genetics of imported stock
- poor sanitation practices for manure disposal, fly control and drying of all floor surfaces
- lack of sufficient quarantine, to minimise spread of disease while heifers are still susceptible
- lack of knowledge and management skills to address problems during calving
- difficulty of supplying optimum diet during early lactation to reduce live weight loss, hence lactation anoestrus
- minimising environmental stress during early lactation so newly calved heifers can cycle normally after two months.

Other factors to consider include:

- selection of the most appropriate heifers prior to transport
- providing good calf and heifer rearing management so calves from imported heifers are well grown and have the opportunity to express their true genetic merit when milking.

19.5.1 Genetic merit of imported stock

The decision on the most appropriate type of stock to import should be seriously considered. Selection of high-genetic merit heifers or cows to import means farmers will need to improve their feeding management to provide sufficient energy to allow these animals to better express their superior genetic merit. This is very important in early lactation when such stock are expected to cycle as well as to produce high levels of milk.

Cows can produce the same milk yield in early lactation with whole body energy balances ranging from +4 to –25 MJ/d. This is the energetic equivalent of 0.8 L milk to build body reserves or to lose the energy derived from losing of 0.8 kg/d of body weight. Clearly cows that are genetically 'programmed' to lose excess weight in early lactation are less desirable in small holder systems where feed shortages are all too common.

Perhaps it would be wiser to import stock of lower genetic merit and then feed them to produce less milk, but at least improve their chances of getting back in calf within 100 days post-partum. The best farmers in Australia can achieve 58% 100-day in-calf rates (Morton *et al*. 2003), compared to only 40% in a well-managed farm in Vietnam (Moran and Tranter 2004).

It is not uncommon for South-East Asian importers of Friesian heifers from Australia to request '5000 litre heifers' (ie heifers likely to produce 5000 L during their first lactation on their home farm). It is highly likely that, once in their new farm in South-East Asia, such animals would be capable of producing only 2000 or 3000 L during their first (and even later) lactation given the existing feeding management. If such animals managed to produce 25 L/d in peak lactation (as a starting point to achieve their 5000 L first lactation yield), their daily energy deficit would be highly likely to impair their 100-day in-calf rate.

19.5.2 Importing young heifers

The high cost of importing pregnant heifers makes alternative methods of increasing cow numbers feasible. For example, consideration could be given to purchasing heifer calves, growing them out for say 6 to 12 months in the exporting country prior to their importation. Granted, this will only supply one animal, compared to the heifer plus embryo when importing pregnant heifers, and delay initiating income, but this will allow an additional 12 months for adaptation to the new environment, prior to calving.

Such adaptation includes adjustment to the climate, feeds, management regime and developing resistance to local parasites and diseases. Over the short term, importing pregnant heifers may give higher returns, but for the long term, importing younger heifers may be more economic (McDowell 1994).

This discussion does not even consider the greater susceptibility of high-genetic merit cows to their physical environment. High milk yields, through increased feed intake, generate more internal heat, thus requiring a less stressful environment to dissipate such heat. Therefore, unless such cows are allowed to regain their normal heat balance, their appetite will fall, hence they will eat less. The only way they can produce milk close to their desired level is by partitioning body reserves towards milk synthesis, thereby increasing energy deficits through greater live weight losses.

It is then likely that these animals will be unable to produce their target milk yields and will not easily get back in calf. Such animals are generally more susceptible to other constraints of the tropical environment. This further increases their likelihood of being culled as non-productive animals. Even if their high purchase cost and their 'status' as exotic cows reduces pressures to cull them, they will become poorer investments compared to locally adapted, and hence stock with less production potential.

19.5.3 The renewed relevance of embryo transfer technology

The practice of Multiple Ovulation and Embryo Transfer is only slowly being accepted in Western dairy industries as another method to more rapidly improve genetic merit, albeit mainly in the pedigree dairy industry. The general consensus is that this technology is not yet a sound economic approach for widespread use in dairy operations whose entire or main business is selling milk (McDowell 1994).

However, for large-scale multiplication of national herds, where genetic progress is less of an issue, and where in their new country as lactating cows, imported heifers cost two to three times more than their original purchase cost, multiple ovulation and embryo transfer may have an economic role. Countries such as China are assessing its relevance to national industry development.

19.5.4 Satisfying customer demands

What the customer wants is often not what the customer needs. Furthermore, what the customer needs may differ even from what the customer gets (Moran 2005).

What the customer wants

Generally, the importer wants firstly, to increase herd numbers in the region being serviced, and secondly, to improve the genetic merit of the milking cows in that region. The first can be achieved by importing any type of dairy animal that will produce milk and reproduce under the existing environmental and production constraints.

Depending on the market demand for the raw product, the imported stock can produce:

1. relatively low quantities of high solids milk, if it is destined for industrial processing to yield dairy products such as milk powder
2. higher yields of milk with lower milk solids, if it is destined for consumption within a few days or even if it is to be processed into long shelf-life products to which imported milk powder can be added.

Milking cows must also routinely produce calves, either as herd replacements or for sale, plus have a disposal value as a cull cow. This can influence the preferred breed because purebred and crossbred Friesians have a higher value for dairy beef than Jerseys or Zebus.

The purchaser may have a set of specifications, some of which are poorly related to production, such as coat colour (eg four white feet and white tip of tail) and udder shape (particularly for cows being milked by hand rather than machines). Large body size should be less of a selection criterion with poorer feeding management and may even be negatively related to performance and longevity in some small holder milking herds. It should be explained to the purchaser which of these selection criteria are the most relevant to the farming system to which the stock will eventually be subjected.

Some contracts may require printed proof of the cow's ancestry, such as the pedigree of its Friesian sire and proof of some stipulated minimum milk yield of its dam. As many of the farmers supplying export stock do not record such data (whose value to the importing country must frequently be questioned), this will limit the number of stock acceptable for export.

Rather than seeking pregnant heifers, some importers prefer younger virgin heifers, with minimum live weights, such as 9 to 16-month-old Friesian heifers weighing from 200 to 360 kg.

What the customer needs

The purchaser usually requires an 'all round performer'. Initially the imported stock may be well managed but eventually their progeny will enter the general dairy population, hence be subjected to more normal farming systems. The ideal imported heifer and her progeny should then be able to perform equally well, compared to local stock, in both well and poorly managed systems. Therefore, heifers from 'average' rather than 'superior' dams may be more suited to purchaser requirements.

There is continuing debate regarding whether it is better to source genotypes to suit existing systems rather than try and 'fit the system' around the genotype. The challenge of the importer is to match the genetic merit of the stock to those farms most likely to benefit from it.

Certainly the Australian Friesian Sahiwal appears better suited to the humid tropics than the purebred Friesian. Jerseys are a more tropically adapted breed than Friesians, with their smaller body size, black skin, higher density of sweat glands and lower internal body heat production, because of their lower productivity. As well as their suitability, there is increasing interest in exporting countries, such as Australia, in utilising some of the production attributes of the crossbred Jersey × Friesian. These animals may have potential as export heifers, at least until more Australian Friesian Sahiwal become available for sale. Brown Swiss is another breed considered to have tropical adaptation features.

What the customer gets

There is increasing concern in many developed temperate dairy industries that current levels of heifer attrition, through export sales, is eroding the genetic quality of their dairy stock. Replacement heifers are required firstly, to expand these local industries and secondly, to allow adequate culling of inferior stock. Such concerns increase sale prices for export heifers, impacting on supplies of suitable stock to meet export demands.

Unlike in other countries, many Australian dairy farmers do not use Friesian bulls or semen over their replacement heifers, often preferring Jerseys or Angus breeds because of small Friesian heifer size at mating. Furthermore, such crossbred progeny have high sale value as week-old calves. The use of Jersey sires is likely to be greater, with current interests in crossbred milking cows, thus reducing the availability of purebred Friesians, the current genotype of choice for export.

Over the last five years sourcing stock for export has been made easier as farmers offload their excess replacements during droughts or when leaving the industry. However, such supplies are abnormal compared to more normal years, when farmers require 25% to 30% of their heifers as herd replacements. How long the current rate of supply of dairy heifers will be available to meet the increasing demands for export must also be addressed.