April 2014

Issue 21

Technical Series

Achieving wintering system performance targets

DairyNZ

BCS GAIN | STAND-OFF SURFACES | COLDNESS CONCERN

Contents

ISSN 2230-2395

DNZ04-021

In this issue of the *Technical Series*...

This *Technical Series* focuses on the management of dry dairy cows over winter (wintering) and how critical it is in New Zealand's pasture-based, seasonal milk production systems.

It is essential to achieve the recommended body condition score (BCS) targets for calving to optimise milk production, reproduction and animal health and welfare in the next lactation. During winter, dairy cows may be required to gain at least 0.5 BCS units prior to calving and the subsequent lactation.

Consequently, wintering systems have evolved to fit the feed supply patterns and production systems of different dairying regions.

In recent years, wintering practices have come under increased scrutiny from the New Zealand public regarding environmental and animal welfare concerns. As a result, facilities that allow animals not to have to graze (crops or pasture) in winter have become more common.

These off-paddock systems include stand-off pads, wintering pads (long-term facilities), free-stall barns (cubicles) and loose-housed barns (large, open bedded).

This issue of the *Technical Series* reviews recent research focusing on wintering – the importance of achieving BCS targets; management to reduce the effects of cold conditions in grazed wintering systems and the management of off-paddock systems to ensure animal welfare is not compromised.

In the southern South Island, the DairyNZ-led Southern Wintering Systems Initiative has monitored six commercial dairy farms operating a range of wintering systems since 2011.

That project aimed to identify good farm management practices for grazed and off-paddock wintering systems and better understand the impact of wintering system choice on the whole farm system.

The AgResearch animal behaviour group has investigated the suitability of different surfaces in off-paddock systems. Additional research aims to identify management factors to reduce the effect of cold conditions during winter on animal performance.

The work described in this issue is a start to understanding new systems being introduced and evolved for New Zealand conditions. Much remains to be done, including incorporation of knowledge from experiences offshore.

Achieving wintering system performance targets

In New Zealand's pasture-based seasonal milk production systems, winter management of dry dairy cows (wintering) is critical to success.

Key findings

- Plan the transition to winter crops and calculate daily feed allocation carefully.
- Over-estimating crop yield and utilisation results in cows not achieving BCS targets.
- Off-paddock wintering systems provide greater control over feed inputs and BCS gain.
- Weather conditions affect lying behaviour in grazed wintering systems.
- Stocking density and lying surface management influence lying behaviour in off-paddock systems.

Dawn Dalley, DairyNZ Scientist

Wintering systems have been developed to fit feed supply patterns and production systems[1], resulting in a range of grazed and off-paddock systems. In regions with adequate winter pasture growth (Northland, Waikato, Taranaki), cows are mainly wintered on pasture and fed supplement on the milking platform or a support block[1].

Increasingly, these systems also incorporate a stand-off pad to protect pasture during wet periods[2]. In colder, more southern climates with minimal pasture growth or regions with heavy, wet soils, farmers remove dry cows from the milking platform's pastures during winter and feed them on support land, either on forage crops or pasture and supplement[3].

Increasing scrutiny of some wintering practices and concern for the environmental impact of wintering have resulted in the adoption of off-paddock systems that allow animals to be removed from grazing in winter, such as wintering pads (long-term facilities), free-stall barns (cubicles) and loose-housed barns[3] (large, open bedded).

Although off-paddock systems allow more control over feed inputs and minimise treading damage[2], they can pose risks for animal welfare as there is generally less space available per cow compared with outdoor systems and lying surfaces may become wet and dirty[4].

The Southern Wintering Systems Initiative (SWS), led by DairyNZ, was developed to identify good farm management practices across the range of wintering systems currently used in the southern South Island. The impact of wintering systems on cow behaviour and health were key factors measured during the project.

Wintering system impact on animal health

Paddock wintering

A number of animal health factors need to be taken into consideration when grazing forage crops. Bloat, nitrate poisoning, amino acid poisoning, choke and mineral deficiencies are all common ailments experienced when grazing brassicas[5]. Acidosis is common with fodder beet[6].

Poor performance of cattle grazing forage brassica crops often results from insufficient dry matter (DM) intake on a daily basis[7], due to an overestimate of DM tonnage on offer and/or an overestimate of crop utilisation.

Judson and Edwards[7] reported that two-thirds of dry cow herds grazing kale in winter were underfed by 1 kg DM relative to their target intake. In some herds, the allocation was up to 8 kg DM/cow/day below target intake.

Transitioning dry cows onto and off forage crops is important to minimise weight loss and prevent rumen imbalances. Cows may take more than two weeks to adjust to maximum voluntary feed intake following a diet change from predominantly pasture to a diet containing 50% or more of forage crop[5].

The aim of an effective adaptation period is to develop a rumen microbe population that can cope with higher levels of non-structural carbohydrates, low levels of fibre and the possible presence of anti-nutritional factors including nitrates and sulphur compounds[5].

Successful transitioning can be achieved by planting a crop paddock on the milking platform and grazing it with lactating cows for one to two hours per day for the last 10 days of lactation. Or, by allocating more supplement and pasture to the diet in the first seven days of the winter grazing period.

Off-paddock wintering

Off-paddock systems increase the risk of animal health problems, including some forms of mastitis and lameness[8]. A survey of New Zealand farmers with stand-off facilities found that 51% directly associated their use with animal health problems.

Table 1.

Area per cow, lying behaviour, average lying time and lying bout length of cows on six dairy farms in Southland and South Otago during winter (Average of 2011 and 2012).

		Indicator			
Wintering system	**Lying surface**	**Area per cow (m^2/cow)**	**Average lying time (hour/cow/day) (Mean ± standard deviation)**	**Less than 8 hours lying (% cows)**	**Short-duration lying bouts (number/day) (Mean ± standard deviation)**
Off-paddock:					
Loose-housed barn	Slatted concrete	4.3	9.0 ± 2.1	67	2.0 ± 2.5
Loose-housed barn	Sawdust	5.2	8.7 ± 1.6	28	5.5 ± 4.2
Free-stall barn	Rubber matting	8.0	11.5 ± 2.1	5	2.4 ± 3.5
Wintering pad	Bark chips	12.0	10.9 ± 1.3	3	7.0 ± 6.0
Wintering pad	River stones and straw	6.3	10.4 ± 0.4	0	4.8 ± 4.7
Grazing:					
Crop (kale)	Soil		9.6 ± 1.0	28	15.9 ± 9.7
Crop (swedes[1])	Soil		10.7 ± 1.5	0	8.7 ± 7.0
Crop (fodderbeet)	Soil		10.6 ± 1.4	5	8.2 ± 7.01
Crop (swedes[2])	Soil		11.5 ± 1.4	0	1.3 ± 1.5
Pasture	Pasture		11.9 ± 0.5	0	0.5 ± 0.3

Lameness was the most common health issue when concrete stand-offs were used and mastitis was with woodchip pads[4]. Hock lesions and swollen pasterns are seen more frequently in confined cows than those on pasture but this is usually a consequence of poor design and construction.

Ensuring cows are dried off correctly before utilising wintering pads or barns will help minimise the risk of mastitis, as will the use of dry cow therapy and teat sealants. Management of the lying surface is also important to reduce the incidence of mastitis.

The required frequency of replacement and cleaning will be dependent on the bedding material used. For cows held in off-paddock systems for extended periods, a minimum loafing area of 6 m^2/cow is recommended to minimise animal health risks.

Wintering system impact on lying times

Insufficient time spent lying results in physiological stress and behavioural signs of frustration in dairy cows. Sufficient lying time is an important objective in dairy management systems[9].

When non-lactating pregnant dairy cows restricted to lying for 3.9 hours/day were compared with those with free choice lying, there were significant physiological differences. These indicated that the stress from lying deprivation was sufficient to suppress the immune response and increase the risk of disease[10].

Paddock wintering

Usually, under acceptable weather conditions, the lying behaviour of grazed dairy cows is not considered to be at risk of compromise. Cows at pasture typically lie for 8-12 hours per day.

Figure 1.

Average daily lying time of cows grazing a crop during winter 2011. Monitoring coincided with a snow storm on day seven.

Standard deviation

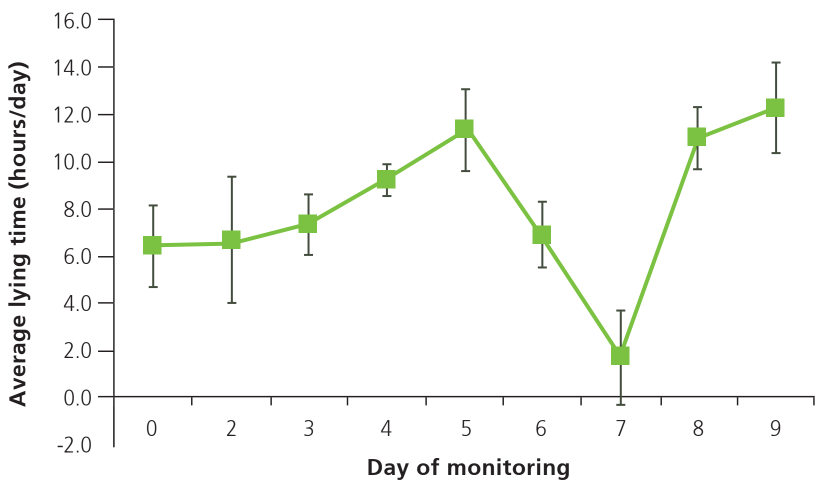
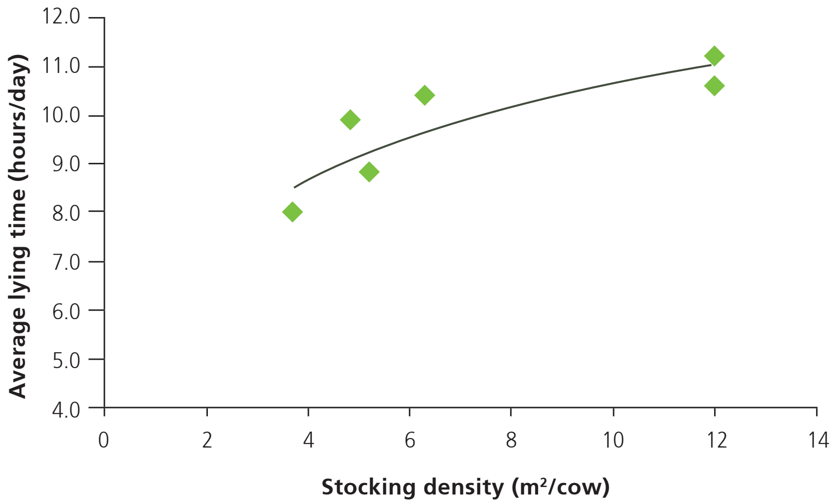


Figure 2.

Relationship between average lying time (hours/ day) and stocking density observed for cows wintered on a wintering pad or in loose-housed barns in the Southern Wintering Systems Initiative.

This shows a general trend for increased lying times as space allowance increased.



Monitoring on four Southland farms as part of the SWS Initiative recorded an average lying time of 10.6 hours per day (range 8.1 to 12.4) for cows grazing kale, swedes or fodder beet, while cows grazing pasture averaged 11.9 ± 0.5 hours per day (Table 1).

Cows wintered on pasture had significantly fewer lying bouts of short duration (lying bouts less than two minutes) than those wintered on crop (Table 1). Duration of lying bout is an indicator of lying surface comfort. If cows are comfortable, lying bouts tend to be longer.

Results from the SWS Initiative suggest that cow comfort on crop paddocks was compromised relative to pasture. Crop paddocks often become very muddy, so cows will choose to lie close to the crop itself, where the surface is drier than the rest of the paddock, and may be more comfortable[4].

Managing crop paddocks to minimise pugging by using back fences and grazing wetter paddocks when conditions are drier is recommended.

Daily weather conditions also have a large impact on lying behaviour. Monitoring on a crop paddock in winter 2011 coincided with snow and resulted in a significant reduction in the lying time (Figure 1).

The cold conditions and limited lying would have increased energy requirements during this period. Farmers need to adjust the daily feed allocation during such events, to minimise the impact on cow performance.

Off-paddock wintering

Lying times observed during monitoring of off-paddock systems were variable between farms and between years within farms (Table 1). Of considerable importance appears to be the space allowance per cow and the surface type and management.

The lowest average lying times and highest percentage of cows not achieving the target were observed with cows in a loose housed barn with a slatted concrete floor. Average lying time was 1.9 hours/day longer in year two, when the area provided was increased by 1.2 m^2/cow. There was a general trend for increased lying time as space allowance increased (Figure 2).

Where individual bedding areas are not provided, overall space allowance becomes important due to competition for a safe and comfortable lying space.

If a pad or barn is being used for up to 12 hours per day, cows must be provided with a comfortable lying area allowing a minimum of 6 m^2/cow[11]. If it is being used permanently with no grazing, a minimum of 8 m^2/cow plus a 1 m^2 feeding area per cow is recommended.

Cows in a loose-housed barn with sawdust or woodchip bedding, that had become wet during winter, had a higher number of short duration lying bouts in both years, indicating some discomfort from the lying surface.

There is good evidence that cows prefer dry, comfortable surfaces to support adequate resting times[12]. Off-paddock facilities should provide lying areas that are comfortable, clean, well-drained and dry. Surfaces should provide grip to support standing, but not be abrasive.

Good stockmanship can overcome some deficiencies in design, suggesting that management is an important determinant of success for the animals[13]. However, choice and design of the facility should consider the intended purpose, pattern of use and stock class to maximise the chance of achieving animal welfare targets.

Conclusions

Crop wintering systems require attention to detail with transitioning and daily feed allocation to ensure achievement of pre-calving BCS targets and minimise the risk of compromising animal welfare.

For off-paddock wintering systems, successful integration within the overall farm system is influenced by the choice of facility, animal factors and the skills of the stock managers. Stocking density and management of the lying surface are critical factors to get right if animal welfare targets are to be achieved.

Fast facts

- Cows may take more than two weeks to adjust to maximum voluntary feed intake following a diet change from predominantly pasture to a diet that contains 50% or more of forage crop.
- A survey of New Zealand farmers with stand-off facilities found that 51% directly associated their use with animal health problems.
- If a pad or barn is being used for up to 12 hours per day, cows must be provided with a comfortable lying area allowing a minimum of 6 m^2/cow.
- If a pad or barn is being used permanently with no grazing, a minimum of 8 m^2/cow plus a 1 m^2 feeding area per cow is recommended.

Feeding for condition score gain

Failing to plan, is planning to fail

With the current high milk price and the prospect of a lower price next season, there is a desire to milk for as long as possible into autumn.

Key findings

- Achieving the recommended body condition score (BCS) targets is important to optimise milk production, reproduction, health and welfare.
- Energy is only partitioned to BCS when maintenance, activity, pregnancy and milk production demands are already met.
- Cows in cold and wet conditions require additional energy for maintenance, and thin cows require more energy than fat cows.
- Cows need time to gain BCS. They gain almost no BCS in the month before calving and often lose BCS in the two weeks following drying off. Even well-fed cows will not gain more than 0.5 BCS unit in a month.
- Different feeds have different efficiencies for BCS gain in the dry cow.
- Lower BCS cows must be dried off earlier to reach target BCS at calving.

Jane Kay, DairyNZ Scientist
Sean McCarthy, John Roche and Kevin Macdonald, DairyNZ

The main objective of management in the last third of lactation is to set the cow up for the following lactation. This requires a focus on body condition score (BCS).

BCS targets have been defined from decades of research in New Zealand and internationally.

To optimise farm management (i.e. milk production, reproduction, health), mature cows should be BCS 5.0 at calving, with first and second calvers at 5.5 BCS[1].

To achieve these BCS targets, cows must:

- have sufficient feed to eat above the requirements for maintenance, milk production, pregnancy and activity, *and*
- have enough time to increase BCS.

The fact that cows require a certain amount of feed to gain one BCS unit is clearly understood, however the amount of time needed is often forgotten[2]. Modern dairy cows and, in particular, the thinnest cows, do not partition much energy to BCS while milking[3].

These cows must be dried off early to have sufficient time dry to gain condition for optimal BCS at calving.

BCS and animal welfare

Recent research by DairyNZ and AgResearch has shown that animal welfare is more likely to be optimal when cows calve at the recommended targets[4].

Cows fatter than recommended had a higher risk of metabolic diseases, such as ketosis, while thinner cows were at a greater risk of infectious or inflammatory diseases, such as uterine infections. Thinner cows were less able to compete for scarce feed resources, prolonging hunger and further increasing the risk of disease[4].

Thin cows at calving become even thinner cows at peak milk production[1]. In the Dairy Cattle Code of Welfare, any animal below BCS 3.0 must be managed immediately to increase BCS.

Although well-managed farms will sometimes have a small proportion of thin cows because of health issues (e.g. mastitis, metritis or lameness cases), ensuring that young and mature cows calve at the correct BCS minimises the need for intervention.

BCS and cold stress

The importance of maintaining cows in good condition is greater in colder climates. In these situations, subcutaneous body fat (just beneath the skin) acts as an insulating layer between the animal's core and the environment. Therefore, cows in good BCS are better able to withstand cold.

Even when cows have adequate condition reserves, there is a temperature below which the animal must increase its metabolic rate to supply more body heat and maintain a constant core body temperature (i.e. the lower critical temperature). This means that maintenance energy requirements increase.

In New Zealand, if a cow is clean and dry and there is little wind or rain, cold stress is rare until ambient temperatures fall below -10°C. However, rain, wind and mud will result in cold stress at higher temperatures and extra energy is required for heat production.

For example, if the ambient temperature is 2°C and a wet cow is exposed to wind and rain in a muddy environment, an additional 16 MJ ME (or approximately 1.5 kg DM/day) is required just to maintain body temperature. This is on top of the usual maintenance, pregnancy and BCS requirements, and needs to be taken into consideration when determining feed allocation in colder weather.

Strategies to achieve BCS gain

There are four main strategies to achieve BCS gain:

1. increase feed allocation to lactating cows
2. once-a-day (OAD) milking
3. dry off at-risk cows early
4. feed dry cows for BCS gain.

At this stage of the season, it is too late to rely on the first two options. Increasing feed allowance or supplementing lactating cows has only a small effect on BCS gain, because genetic

Table 1.

Approximate amounts (kg DM) of commonly used feeds required for a 1.0 unit increase in BCS (*DairyNZ body condition scoring reference guide*)[7].

These are requirements above maintenance, activity and pregnancy requirements. They do not include wastage. Estimates of wastage can be found in the DairyNZ *Facts and Figures*, pg 31.

Breed	Kg Lwt[1]	Kg Lwt/ BCS	Autumn pasture	Pasture silage	Maize silage	PKE	Kale[2]	Swedes[3]	Fodder beet[2]
			MJ ME/kg DM						
			11.5	**10.5**	**10.5**	**11**	**11**	**12**	**12.5**
Jersey	350	23	145	110	115	85	150	125	110
Jersey	400	26	165	130	130	100	175	145	125
Crossbred	450	30	185	145	145	110	195	160	140
Holstein Fresian	500	33	205	160	160	125	215	180	155
Holstein Fresian	550	36	225	180	180	135	235	195	170

[1]Live weights are for the cow only and exclude the weight of the foetus.
[2]Requirements for kale and fodder beet were estimated relative to requirements for grass silage from Keogh et al. (2008).
[3]Requirements for swedes were estimated as the average of kale and fodder beet.

selection over several decades has resulted in cows that partition energy to milk at the expense of BCS.

DairyNZ research found that feeding an extra 3 kg DM/day of a high energy concentrate to a lactating cow for 100 days in autumn only increased BCS gain by 0.12 BCS units[3].

Additionally, OAD during late lactation only has a small impact on BCS gain. In a recent experiment, cows milked OAD for 84 days in late lactation were only 0.25 BCS units greater at dry-off than those milked twice-a-day[5].

Now is the last opportunity to implement a plan for BCS gain. This plan should include: when to dry cows off and how much to feed them when dry.

Feeding dry cows for BCS gain

Compared with a lactating cow, a dry cow gains BCS more efficiently because she does not have the energy demand of milk production and has lower activity and maintenance requirements.

Different feeds are used with differing efficiencies in the dry cow. The amount of different feeds required to gain one BCS unit is presented in Table 1.

A critical factor in managing BCS gain in dry cows is the time required for a cow to gain BCS. Two things are important:

1. A dry cow will not gain BCS for one to two weeks after drying off, due to the active immune response involved in the drying off process. This is often exacerbated by underfeeding these cows unnecessarily.
2. Dry cows gain very little BCS during the month before calving (less than 0.1 BCS units) because of the large energy demands of the growing calf[1]. Research results indicate that feeding more than maintenance during the month before calving to try and gain additional BCS can increase the risk of metabolic disorders post-calving[6].

Therefore, there are approximately 40 days during the dry period that a cow does not gain BCS. This needs to be taken into consideration when developing the feeding strategies for BCS gain.

Feed requirements per day

Figures 1a and 1b show how the days available during the dry-period to gain BCS can affect the cow's ability to achieve BCS targets. ▶

Figure 1a and 1b.

The approximate amount of pasture and supplement required for maintenance, pregnancy and one BCS unit gain for a 450 kg crossbred cows at eight weeks pre-calving. The three vertical bars represent dry off at either 120, 90 or 60 days pre-calving. These values represent required feed eaten and do not include any wastage. The blue bar is the potential intake of a dry cow on these feeds[2]. The figures show that cows cannot consume enough energy to gain one BCS if the dry period is not at least 90 days.

Figure 1a: Pasture + pasture silage

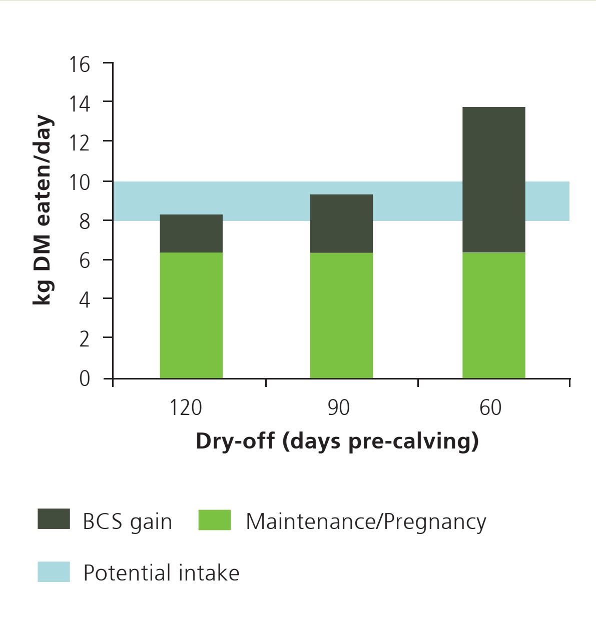


Figure 1b: Pasture + PKE

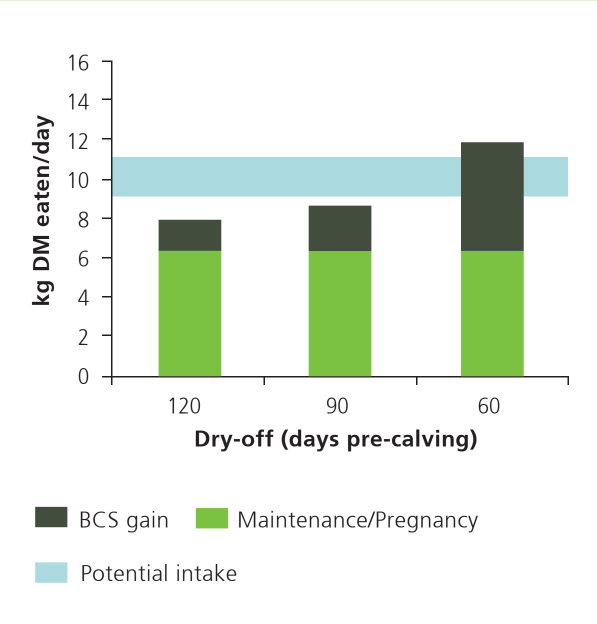


Figure 1a is an example of a 450 kg crossbred cow dried off at 120, 90 or 60 days pre-calving, at BCS 4.0. The vertical bars represent required feed eaten/day at eight weeks pre-calving to gain one BCS unit.

If dried off at 90 days pre-calving, she has approximately 50 effective days to gain one BCS unit. This means that at eight weeks pre-calving, if she was fed pasture and pasture silage, she will need to eat 9.3 kg DM/day in total.

In this example, this is made up of 6.4 kg DM pasture/day for maintenance and pregnancy (*DairyNZ Facts and Figures*)[8] plus 2.9 kg DM pasture silage/day for BCS gain.

In comparison, if this cow is milked for longer and dried off at 60 days pre-calving, at eight weeks she will need to eat 13.7 kg DM/day. This is made up of 6.4 kg DM pasture/day for maintenance and pregnancy, plus 7.3 kg DM pasture silage/day for BCS gain.

Based on these assumptions, cows cannot consume enough energy to gain one BCS if the dry period is not at least 90 days. This is indicated by the blue bar on the figure which represents the typical intake of a dry cow being offered pasture and pasture silage (Figure 1a).

Best feeds for weight gain

New Zealand research indicates there are different efficiencies for BCS gain with different feeds during the dry period (Table 1[2]). The energy in autumn pasture is used less efficiently for BCS gain compared with pasture silage, maize silage or PKE.

Figure 1b is the same 450 kg crossbred cow fed pasture and PKE.

If dried off at 90 days pre-calving and needing to gain one BCS unit, at eight weeks pre-calving she will need to eat 8.6 kg DM/day in total. This is made up of 6.4 kg DM pasture/day for maintenance and pregnancy plus 2.2 kg DM PKE/day for BCS gain.

Once again, if she is milked for longer and dried off 60 days pre-calving, at eight weeks pre-calving she will need to eat 11.4 kg DM/day. This is made up of 6.4 kg DM pasture/day for maintenance and pregnancy plus 5.0 kg DM PKE/day for BCS gain.

Therefore even when using a feed such as PKE, that is more efficient for BCS gain in dry cows, cows cannot eat enough on a daily basis to gain one BCS unit with a 60-day dry period.

Conclusions

Although the days to gain one BCS unit are dependent on feed type and amount of feed consumed, the examples emphasise the importance of drying cows off with enough time to gain BCS to reach calving targets.

Ideally, strategies to reach BCS targets should be put in place in early autumn. However, now is the final chance to action a plan which may enable these targets to be met. This should involve assessing the herd's BCS and making decisions on drying cows off, feed type and feeding level.

Achieving the recommended body condition score (BCS) targets is important to optimise milk production, reproduction, health and welfare.

Fast facts

- There are approximately 40 days during the dry period that a cow does not gain BCS.
- Cows fatter than recommended have an increased risk of metabolic diseases, such as ketosis, while thinner cows have greater risk of infectious or inflammatory diseases, such as uterine infections.
- Lower BCS cows must be dried off earlier to reach target BCS at calving.

The effects of stand-off surfaces

Adequate resting is very important for dairy cows and they need 8-12 hours per day lying down.

Key findings

- Lying time is an important behaviour for dairy cows and a good measure of successful stand-off management.
- Failure to achieve minimum lying times will compromise welfare and reduce stock performance.
- Cows are reluctant to lie on hard or wet surfaces such as concrete or mud, both of which are unsuitable as stand-off surfaces.
- Woodchip surfaces enable cows to achieve normal lying times of 8-12 hours/day.
- Rubber matting over concrete encourages longer lying times, but thicker rubber (24 mm) is more successful than thinner (12 mm) and is recommended for stand-off facilities. Attention is needed for cow cleanliness and hygiene while on rubber.
- Stocking density affects lying time on 24 mm rubber mats, with 4.5 m^2/cow necessary to achieve the minimum lying requirement (with six hours per day of pasture access) and 6 m^2/cow supporting daily lying times equivalent to cows on pasture.

Jim Webster, AgResearch Ltd
Karin Schütz, AgResearch Ltd

If lying time is less than eight hours, signs of physiological stress and behavioural frustration result[1, 3, 4]. Lying time is, therefore, often used as a measure of welfare. Conditions that disrupt a cow's lying behaviour include hard or muddy surfaces, cold conditions or disturbance from other cows.

While there is generally plenty of opportunity for cows to rest while at pasture, it is becoming common in New Zealand for cows to spend more time out of the paddock to protect pasture, to reduce soil damage and improve the feeding of supplements.

In these off-paddock systems, there is more potential for disruption to cows' lying needs resulting in stress, welfare compromise and lower production. ▶

Importance of comfortable surfaces

The importance of a comfortable stand-off area for cow health and welfare has been known for some time[2, 6].

These studies compared indicators of welfare for cows on the main stand-off surfaces used at that time: woodchip pad, concrete yard, gravel laneway or sacrifice paddock. The usage pattern tested was to stand cows off for 21 hours, with three hours access to pasture per day. Normal lying times were only achieved on the woodchip pad, demonstrating that cows were reluctant to lie on hard or muddy surfaces.

There was also evidence of a physiological stress response and more lameness in the cows given concrete as a stand-off surface. The cows become dirtier, due to mud and faeces, which lowers animal hygiene and increases risk of infectious disease.

A subsequent study looked more closely at the consequences of standing cows off pasture on concrete, simulating a potential stand-off regime in winter[7].

For seven days, cows were held on a concrete pad for 18 hours, with six hours pasture access each day. Cows were then given a week on pasture before the stand-off week was repeated. The study showed that cows were reluctant to lie down on concrete, taking twice as long to lie down compared with cows on pasture (5.5 hours vs two hours).

On the first day of stand-off, cows lay down for only 3.2 hours, showing that the effects start immediately. The average daily lying time while on concrete was only 6.4 hours a day compared with 12.4 hours a day on pasture. Cows on concrete compensated for their lack of lying time by choosing to lie down on pasture instead of grazing, both during their daily pasture access period and then during their recovery week.

On the first day of recovery, they lay down for almost 16 hours. As a consequence, their rate of liveweight gain was lower. The effects of standing off on concrete were more pronounced during the second week of stand-off, indicating that the cows had not fully recovered from the first stand-off period during the recovery week on pasture.

The impact of standing off on an uncomfortable surface was, therefore, long-lasting, which is best depicted by the cumulative deficit in lying time of cows on concrete compared with cows on pasture (Figure 1.). By the end of the study, the cows stood off on concrete had lain down 46 hours less than cows on pasture.

Finally, the stress response of the cows was tested by one hour of road transport a week after the second stand-off period. Cows stood-off on concrete had a heightened cortisol response, indicating their physiology was still affected by the stand-off management and potentially putting them more at risk from health issues.

Suitability of rubber surfaces

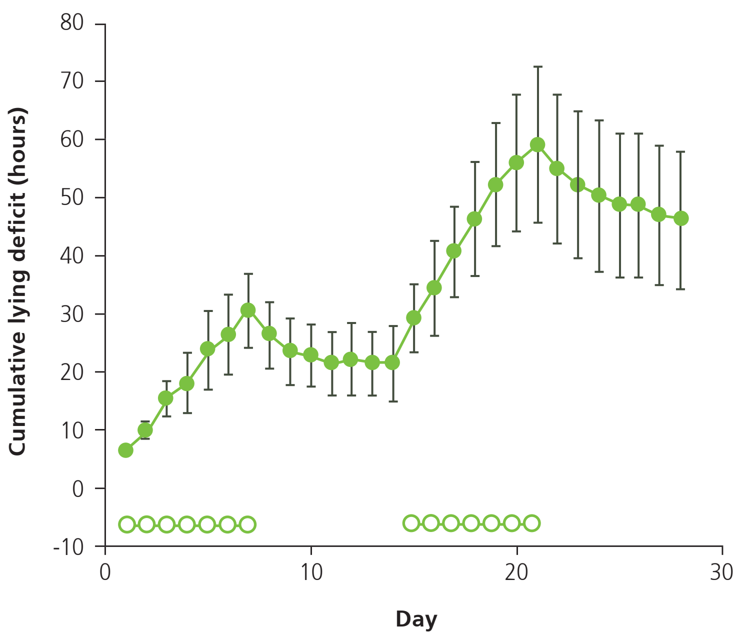
Despite the evidence that well-managed woodchip surfaces are good stand-off surfaces for cows from a health and welfare perspective, there are a number of issues around their use.

Woodchip systems can be costly or difficult to procure, require careful management (such as stocking density), their lifetime can

Figure 1.

Cumulative lying deficit calculated as the difference in lying hours between cows stood-off on concrete for 18 hours per day for two seven-day periods (open circles) compared with cows grazed on pasture. Vertical bars represent the standard deviation.

This shows that cows deprived of enough lying time do not adjust or compensate even after a recovery period of one week.



○ Two seven-day periods of stand-off

I The standard deviation

vary and dealing with the woodchip at the end of its life can be problematic. Furthermore, many farmers already have large areas of concrete available and would like facilities that are flexible.

More recent studies have focused on the use of rubber surfaces applied over concrete, as a possible solution to the problem of bare concrete being so unsuitable for stand-off.

In the first of these studies[5] four surfaces were compared – bare concrete; woodchips; concrete covered with 12 mm rubber matting (Agrimat Uni, 1190 x 850 x 12 mm interlocking mat, Numat Ltd, Auckland, New Zealand) and concrete covered with 24 mm rubber matting (Agrimat Kura, 1190 x 850 x 24 mm interlocking mat, Numat Ltd).

The stocking density on all surfaces was 4.9 m^2/cow. A stand-off regime of 18 hours off pasture and six hours on pasture for four days, followed by seven days on pasture, was used. This pattern was repeated four times to simulate repeated short periods of stand-off during winter.

As expected from previous work, during the period of stand-off, cows on woodchips lay down the most (10.8 hours) and those on concrete the least (2.8 hours). The interesting question was whether the rubber mats would improve lying time on concrete and, if so, by how much?

The results showed lying times of six hours on the 12 mm rubber and 7.3 hours on the 24 mm rubber – far better than bare concrete but not as much as on woodchip.

While the lying times on rubber mats were less than the recommended minimum of eight hours per day for dairy cows, when the time on pasture each day was included, the total daily lying times reached this minimum on 24 mm rubber (8.1 hours) but not on 12 mm rubber (6.9 hours).

As shown previously, cows not lying long enough attempted to compensate by lying more during the daily and weekly periods on pasture, but did not fully reach the lying times of cows stood off on woodchips.

Dirt scores of cows on rubber surfaces were almost three times greater than for cows on concrete or woodchip. Cows on the concrete treatment in this study showed signs of poorer leg health (gait score and stride length) which adds further weight to the unsuitability of this surface for stand-off use.

Studying stocking densities

The latest study was designed to provide recommendations on suitable stocking densities on the same 24 mm rubber mat and stand-off regime (18 hours/day) used previously. This time a slightly different pattern of winter use was tested, comprising three days of stand-off followed by six days on pasture, repeated six times.

Six different stocking densities were compared – 3 m^2, 4.5 m^2, 6 m^2, 7.5 m^2, 9 m^2 and 10.5 m^2/cow. Only a preliminary analysis of the results has been completed, but it indicates a clear effect of stocking density on lying time, with cows lying for longer at higher space allowances, i.e. lower densities.

The recommended daily minimum lying time for dairy cows (eight hours) was achieved at 4.5 m^2/cow, but only when the lying time during the six hour period on pasture was included.

Total lying time, while meeting the minimum requirement, was still less than the average lying time for these cows when on pasture alone (47% of the time lying) and this was achieved at the next lowest stocking density of 6 m^2/cow (the recommended minimum).

Conclusions

Lying is a very important behaviour for dairy cows and a useful measure of cow comfort and welfare. If cows cannot meet required minimum lying times due to unsuitable conditions they may suffer serious health and welfare problems.

It is clear that cows are reluctant to lie on hard or wet surfaces such as concrete and mud and, as a result, their welfare is compromised quickly when held on these surfaces. Well-managed woodchip surfaces support normal lying behaviour, but can be costly or difficult to manage.

Existing concrete surfaces can be made more attractive for cows to lie on with thicker rubber (24 mm) likely to be more favoured than thinner rubber (12mm). Care must be taken with stocking density to achieve the desired lying times and a greater risk of poor hygiene on rubber needs to be managed.

Fast facts

- The average daily lying time while on concrete was 6.4 hours compared with 12.4 hours on pasture.
- By the end of the study, the cows stood off on concrete had lain down 46 hours less than cows on pasture.
- The recommended minimum lying time is eight hours per day for dairy cows.

Coldness as a cow welfare concern

Coldness is a familiar and unpleasant sensation for most people, and is also a welfare concern for dairy cows in New Zealand.

Key findings

- Behavioural and physiological responses to cold conditions can lead to poorer welfare and productivity. Thinner cows are more susceptible.
- Physiological responses to cold include stress responses, mobilisation of fat reserves, altered body temperature rhythms, reduced immune function and increased skin thickness.
- Behavioural indications that cows are cold are more obvious and include seeking shelter, increased time standing (possibly with a lowered head), lower feed intake, lying with head or legs tucked against the body and shivering.
- Ways to reduce the effects include providing shelter, extra feed before cold conditions occur, high quality and easily-consumed feed once conditions are adverse, and paying more attention to thin and young animals.
- Providing drier, comfortable lying surfaces is more important during cold conditions to help counter the shorter lying times of cows at this time.

Jim Webster, AgResearch Ltd

Animal welfare concerns have been categorised into three main areas or domains: biological function (health and physiology), affective state (emotions and feelings) and naturalness (ability to live and behave naturally)[5].

The relevance of these domains and the need to ensure welfare expectations are met across all three domains was covered in the *Technical Series*[7] (No.18). These also provide a useful basis to evaluate how a particular issue, such as cold weather, might affect welfare.

Coldness affects all three of the main welfare domains. It produces unpleasant feelings impacting affective state. It can negatively affect an animal's biological functioning, characterised by a cascade of physiological responses in an attempt to cope. An inability to undertake natural behavioural coping responses to cold, such as shelter-seeking, will negatively impact an animal's degree of naturalness.

Management of the potential impact of cold is covered in the World Health Organisation's *'General Principles for the Welfare of Animals in Livestock Production Systems'* which are proposed as a framework to guide animal welfare standards[4,5]. Air quality, temperature and humidity in confined spaces should support good animal health and not be unpleasant to animals. Where extreme conditions occur, animals should not be prevented from using their natural methods of thermoregulation.

Management practices to deal with the effects of cold weather should, therefore, be in place on dairy farms.

While New Zealand has a mild, temperate climate, a feature is changeability and periods of cold and wet weather. Cattle are generally more affected by heat than cold. However, changeable cold, wet and windy conditions make adaptation to cold difficult. Wet weather and wind reduce the natural insulative properties of the coat and the increased rate of heat loss can place cows into cold stress under conditions which might not seem unduly cold.

While New Zealand's pasture-based systems provide welfare advantages through freedom to range and ability to perform natural behaviours, they do increase the risk of exposure to adverse weather conditions. Simulation of a week of cold and wet weather in New Zealand has been demonstrated to cause a welfare challenge even in non-pregnant, non-lactating cows in good condition[12].

Older data demonstrated that heifer growth during winter was improved by shelter[8], while a recent modelling study estimated that milk production was reduced by even a short period of cold conditions (1-3% of days)[1].

Note that this is a production threshold and conditions that are severe enough to affect welfare could occur before production is affected. For these reasons, it is important to recognise signs of coldness in dairy cows and understand how these might impact welfare in order to put strategies in place to mitigate the affects of cold weather.

Effect on biological functioning

Biological functioning is an important component of animal welfare. It is also particularly relevant to farmers, given the direct implications for health and productivity.

Exposure of New Zealand dairy cows to a week of cold and wet conditions (mean 3.4°C, 3 mm of rain for 15 minutes/hour, wind 7.1 kmh^{-1}) produced dramatic effects on the cows' physiology[12].

The daily body temperature pattern, which in sheltered cows had a consistent daily rhythm ranging over approximately 0.2°C, doubled in size under the cold conditions. There was evidence from increases in non-esterified fatty acids and thyroxine (thyroid hormone) that cows were mobilising fat reserves to raise body temperature in the afternoon and evening, and allowing body temperature to fall during the night to a minimum in the early morning.

The cold conditions also caused a stress response characterised by higher cortisol levels in the blood and faeces, and a reduction in white blood cells (particularly lymphocytes and basophils) suggested that immune function was impacted.

A subsequent study in the same facility looked at alternating exposure of cows to a week of cold and wet weather, followed by a week of shelter, for six weeks in winter. The study also examined the influence of cow body condition[11]. The adverse conditions in this study were a mean temperature of 4.9°C with a wind chill of -9.9°C.

Thinner cows had bigger variations in their body temperature rhythm when suffering from lower minimum temperatures, suggesting a heightened cold response in these animals. Consistent with previous findings, cold conditions produced a generalised stress response and cows mobilised fat reserves.

An interesting response was thickening of the skin in cows under cold conditions, a much faster response of this parameter than might be expected. The skin thickness was less in thinner cows. The marked reduction in lying time during adverse conditions, to levels well below normal, will have caused a physiological stress response in itself[3].

Effect on naturalness

Under natural conditions, animals usually seek shelter during adverse conditions. But in many farming situations, shelter options may be limited[6].

Behavioural responses are, nevertheless, part of a cow's natural response to cold and additionally provide a visible indication of the cow's perception of its environment. Cows also respond to cold, wet conditions by reducing the time spent lying and eating. In the study of Webster *et al*.[12], lying time was reduced to around five hours per day, much less than the eight hour recommended minimum for dairy cows.

Reduced lying and feeding behaviour under cold and wet conditions was also found by Tucker *et al*.[11], with a greater response shown by thinner cows. Average lying time was only four hours per day during adverse conditions.

The Tucker study looked closely at the cows' postures and has provided information on the behavioural responses of cows to cold. Under cold and wet conditions, cows are more likely to stand with their head down (particularly thinner cows) and, if they lie down, spend more time lying with their front legs bent, hind legs touching their body and head turned back against their flank or on the ground. Most cows (90%) were also observed to shiver at some point.

Experimental exposure of New Zealand dairy cows to 22 hour periods of either wind, rain, or wind and rain provided an insight into the cow's perception of these different conditions[10]. Cows reduced their lying and feed intake under wet conditions with and without wind.

Wind amplified the impact of wet weather on feed intake. Cows chose to seek shelter approximately half the time under all conditions. Mud is frequently associated with wintry weather and cows are reluctant to lie down on muddy surfaces, therefore accentuating the impact of adverse conditions on lying times[2]. ▶

Effect on affective state

Affective state aspects of welfare involve considering the subjective experiences of animals.

Unpleasant experiences that are severe or persistent reduce welfare and an inability to satisfy the basic drives to reduce those experiences is a further compromise to welfare[9].

While there are no direct and practical measures of subjective experiences in cows, the behavioural responses and the context of those responses can make inferences about affective state. Cows will readily seek shelter during cold conditions and if unable to do so, tend to reduce food intake, stand with their head down or lie in postures that reduce heat loss, with most of these responses more pronounced in thinner cows[11].

These behaviours alone provides good evidence that cows perceive cold conditions as unpleasant and, if unable to escape the cold by sheltering, their welfare will be compromised.

Conclusions

Wintry weather with cold, wet and windy conditions can occur in New Zealand pastoral farming systems and result in physiological and behavioural coping responses of dairy cows.

If not planned for and managed, these conditions can compromise welfare. The three main aspects of welfare concern are all likely to be impacted by cold conditions, placing the public perception of dairying at risk if they are not adequately addressed.

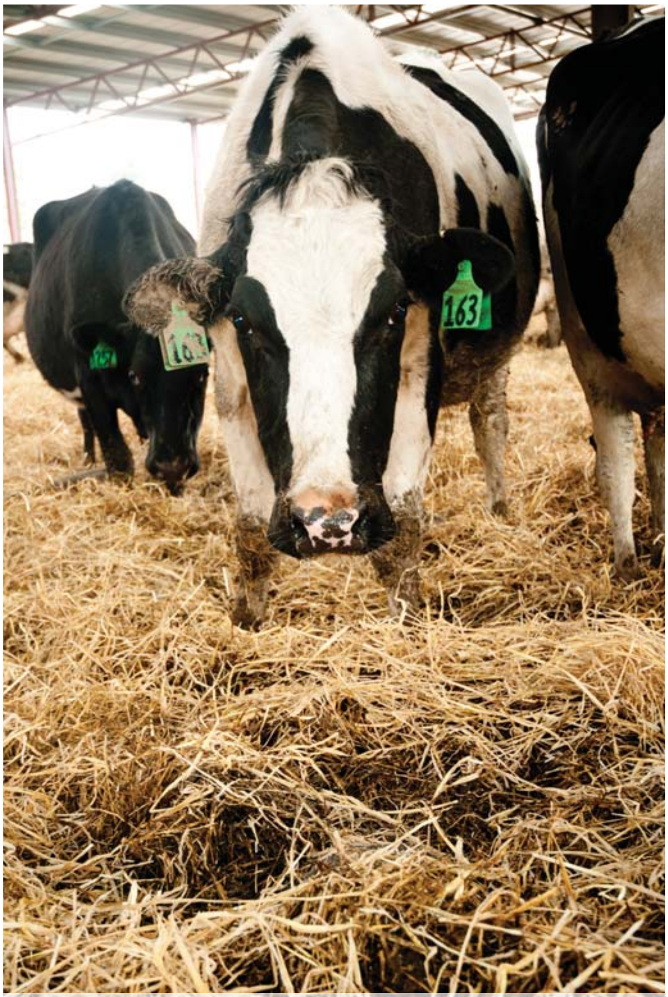
Cows respond to cold conditions by seeking shelter. If unable to, they undergo a number of physiological responses that assist them to cope with the conditions, including mounting a stress response and generating heat by shivering and mobilising fat.

They are more likely to reduce eating and stand during these conditions, particularly with their head down. They will adopt postures indicating they are cold and that may conserve heat, such as turning their head round to their body and tucking their legs in against the body when lying.

Thinner cows are more susceptible to cold and their welfare is likely to be compromised first. Thus, younger animals are also likely to be more susceptible to cold conditions, due to their higher relative heat loss.

Management practices to mitigate the effects of cold include providing cows with shelter, providing high quality and easily-consumed feed once conditions are adverse, and paying particular attention to thin and young animals.

Provision of drier, comfortable surfaces during cold conditions is important to mitigate the impact of reduced lying time and should be part of any stand-off system.



Drier, comfortable surfaces during cold conditions mitigate the impact of reduced lying time and should be part of any stand-off system.

Fast facts

- A recent modelling study estimated that milk production was reduced by even a short period of cold conditions (1-3% of days).
- Exposure of New Zealand dairy cows to a week of cold and wet conditions (mean 3.4°C, 3 mm of rain for 15 minutes/hour, wind 7.1 kmh) produced dramatic effects on the cows' physiology.

References

Achieving wintering system performance targets

1. Holmes C.W., I.M. Brookes, D.J. Garrick, D.D.S. Mackenzie, T.J. Parkinson and G.F. Wilson. 2002. In D. Swain ed. Milk production from pasture. Principles and practices. Massey University.

2. Longhurst R.D., D. Miller, I. Williams and A. Lambourne. 2006. On-farm wintering systems – issues to consider. Proceedings of the New Zealand Grasslands Association Conference 68: 289-292.

3. Dalley D.E. 2011. The challenges of animal wintering from a sustainability perspective. Proceedings of the New Zealand Society of Animal Production 71: 172-177.

4. Stewart M., A.D. Fisher, G.A. Verkerk, and L.R. Matthews. 2002. Winter dairy grazing systems: management practices and cow comfort. Proceedings of the New Zealand Society of Animal Production 62: 44-48.

5. Nichol WW 2007. Nutritional disorders of ruminants caused by consumption of pasture and fodder crops. In: Rattray PV, Brookes IM, Nicol AM ed. Pasture and supplements for grazing animals, New Zealand Society of Animal production. Occasional Publication No. 4. Pp.133-150.

6. Dulphy J.P. and C. Demarquilly. 2000. Fodder beets in animal husbandry. Interet zootechnique de la betterave. Forrages 63: 307-314

7. Judson H.G., and G.R. Edwards. 2008. Survey of management practices of dairy cows grazing kale in Canterbury. Proceedings of the New Zealand Grasslands Association Conference 70: 249-254.

8. Rushen J., A.M. de Passillé, M.A.G. Keyserlingk, and D.M. Weary. 2008. The Welfare of Dairy Cattle. Vol. 5. Animal Welfare, Springer, Dordrecht.

9. Hristov S.B.S., Z. Zlatanović, M. Joksimović, and V.D. Todorović. 2008. Rearing conditions, health and welfare of dairy cows. Biotechnology in Animal Husbandry 24(1-2):23-35.

10. Fisher A.D., G.A. Verkerk, C.J. Morrow, and L.R. Matthews. 2002. The effects of feed restriction and lying deprivation on pituitary-adrenal axis regulation in lactating dairy cows. Livestock Production Science 73: 255-263.

11. Anonymous 1998. Stand-off pads. Livestock Improvement Advisory, Farm Facts No. 3-14. Livestock Improvement Corporation, Hamilton, New Zealand.

12. Fisher A.D., Stewart M., Verkerk G.A., Morrow C.J., Matthews L.R. 2003. The effects of surface type on lying behaviour and stress responses of dairy cows during periodic weather-induced removal from pasture. Applied Animal Behaviour Science 81: 1-11.

13. Bowell VA, Rennie LJ, Tierney G, Lawrence AB, Haskell MJ, 2003. Relationships between building design, management system and dairy cow welfare. Pages 547-552 in Proceedings of the 2nd International Workshop on the Assessment of Animal Welfare at Farm and Group Level. Vol. 12. A. J. F. Webster and D. C. J. Main, ed. Universities Federation for Animal Welfare (UFAW), Wheathampstead; UK

Feeding for condition score gain

1. Roche, J.R., N.C. Friggens, J.K. Kay, M.W. Fisher, K.J. Stafford and D.P. Berry. 2009. Invited Review: Body condition score and its association with dairy cow productivity, health and welfare. J. Dairy Sci. 92:5769-5801.

2. Mandok, K.M., J. K. Kay, S.L. Greenwood, J. P. McNamara, M. Crookenden, R. White, S. Shields, G. R. Edwards, and J.R. Roche. 2014. Efficiency of use of metabolizable energy for body weight gain in pasture-based non-lactating dairy cows. J. Dairy Sci. submitted.

3. Roche, J.R., D.P. Berry, and E.S. Kolver. 2006. Holstein-Friesian strain and feed effects on milk production, body weight, and body condition score profiles in grazing dairy cows. J. Dairy Sci. 89:3532-3543.

4. Roche, J. R., K. A. Macdonald, K. E. Schütz, L. R. Matthews, G. A. Verkerk, S. Meier, J. J. Loor. A. R. Rogers, J. McGowan, S. R. Morgan, S. Taukiri, and J. R. Webster. 2013. Calving body condition score affects indicators of health in grazing dairy cows. Journal of Dairy Science 96: 5811-5825.

5. Kay, J.K., J. Roche, and C.V.C. Phyn. 2014. Effects of once-a-day milking during late lactation on production parameters. NZ Society of Animal Production: in press

6. Loor, J.J., H.M. Dann, N.A. Janovick Guretzky, R.E. Everts, R. Oliveira, C. A. Green, N. B. Litherland, S.L. Rodriguez-Zas, H.A. Lewin, and J. K. Drackley. 2006. Plane of nutrition prepartum alters hepatic gene expression and function in dairy cows as assessed by longitudinal transcript and metabolic profiling. Physiol Genomics 27:29-41.

7. DairyNZ Body Condition Scoring – the reference guide for NZ dairy Farmers. http://www.dairynz.co.nz/page/pageid/2145864561?resourceId=703

8. DairyNZ Facts and Figures for New Zealand Dairy Farmers. http://www.dairynz.co.nz/page/pageid/2145866931/Facts_and_Figures

The effects of stand-off surfaces

1. Cooper, M. D., D. R. Arney, and C. J. C. Phillips. 2008. The effect of temporary deprivation of lying and feeding on the behaviour and production of lactating dairy cows. Animal 2:275-283.

2. Fisher, A. D., M. Stewart, G. A. Verkerk, C. J. Morrow, and L. R. Matthews. 2003. The effects of surface type on lying behaviour and stress responses of dairy cows during periodic weather-induced removal from pasture. Applied Animal Behaviour Science 81:1-11.

3. Fisher, A. D., G. A. Verkerk, C. J. Morrow, and L. R. Matthews. 2002. The effects of feed restriction and lying deprivation on pituitary-adrenal axis regulation in lactating cows. Livestock Production Science 73:255-263.

4. Munksgaard, L. and H. B. Simonsen. 1996. Behavioral and Pituitary Adrenal-Axis Responses of Dairy Cows to Social Isolation and Deprivation of Lying Down. Journal of Animal Science 74:769-778.

5. Schütz, K. E. and N. R. Cox. In Submission. Effects of short-term repeated exposure to different surface types on the behavior and physiology of dairy cattle. Journal of Dairy Science.

6. Stewart, M., A. D. Fisher, G. A. Verkerk, and L. R. Matthews. 2002. Winter dairy grazing systems: management practices and cow comfort. Proceedings of the New Zealand Society of Animal Production 62:44-48.

7. Webster, J. R., P. E. Kendall, L. R. Matthews, K. Schütz, M. Stewart, C. B. Tucker, and G. A. Verkerk. 2007. Management strategies for coping with cold and wet weather on pasture-based dairy farms: productivity consequences of reduced cow comfort. Pages 612-615 in Proc. Meeting the Challenges for Pasture-Based Dairying. Australasian Dairy Science Symposium. National Dairy Alliance, The University of Melbourne, Australia.

Coldness as a welfare concern

1. Bryant, J. R., N. López-Villalobos, J. E. Pryce, C. W. Holmes, and D. L. Johnson. 2007. Quantifying the effect of thermal environment on production traits in three breeds of dairy cattle in New Zealand. New Zealand Journal of Agricultural Research 50(3):327-338.

2. Fisher, A. D., M. Stewart, G. A. Verkerk, C. J. Morrow, and L. R. Matthews. 2003. The effects of surface type on lying behaviour and stress responses of dairy cows during periodic weather-induced removal from pasture. Applied Animal Behaviour Science 81(1):1-11.

3. Fisher, A. D., G. A. Verkerk, C. J. Morrow, and L. R. Matthews. 2002. The effects of feed restriction and lying deprivation on pituitary-adrenal axis regulation in lactating cows. Livestock Production Science 73(2-3):255-263.

4. Fraser, D., I. J. H. Duncan, S. A. Edwards, T. Grandin, N. G. Gregory, V. Guyonnet, P. H. Hemsworth, S. M. Huertas, J. M. Huzzey, D. J. Mellor, J. A. Mench, M. Špinka, and H. R. Whay. 2013. General Principles for the welfare of animals in production systems: The underlying science and its application. Veterinary Journal 198(1):19-27.

5. Fraser, D., D. M. Weary, E. A. Pajor, and B. N. Milligan. 1997. A scientific conception of animal welfare that reflects ethical concerns. Animal Welfare 6(3):187-205.

6. Gregory, N. G. 1995. The role of shelterbelts in protecting livestock: a review. New Zealand Journal of Agricultural Research 38(4):423-450.

7. Harding, N. 2013. Three domains for animal welfare assessment. DairyNZ Technical Series 18:4-5.

8. Holmes, C. W., R. Christensen, N. A. McLean, and J. Lockyer. 1978. Effects of winter weather on the growth rate and heat production of dairy cattle. New Zealand Journal of Agricultural Research 21(4):549-556.

9. Mellor, D. J. 2012. Animal emotions, behaviour and the promotion of positive welfare states. New Zealand Veterinary Journal 60(1):1-8.

10. Schütz, K. E., K. V. Clark, N. R. Cox, L. R. Matthews, and C. B. Tucker. 2010. Responses to short-term exposure to simulated rain and wind by dairy cattle: time budgets, shelter use, body temperature and feed intake. Animal Welfare 19: 375-383.

11. Tucker, C. B., A. R. Rogers, G. A. Verkerk, P. E. Kendall, J. R. Webster, and L. R. Matthews. 2007. Effects of shelter and body condition on the behaviour and physiology of dairy cattle in winter. Applied Animal Behaviour Science 105(1-3):1-13.

12. Webster, J. R., M. Stewart, A. R. Rogers, and G. A. Verkerk. 2008. Assessment of welfare from physiological and behavioural responses of New Zealand dairy cows exposed to cold and wet conditions. Animal Welfare 17:19-26.

Science snapshots

1. Haultain, J., I. Yule, A. J. Romera, B. Dela Rue, D. Clark, C. Glassey, and J. Jago. 2013. Ranking paddock performance using grazing events and milk yield data. Proceedings of the Spatially Enabled Livestock Management Symposium, Camden, Australia, p 29.

2. Minnee, E.M.K., C. E. F. Clark, and D. A. Clark. 2013. Herbage production from five grazeable forages. Proceedings of the New Zealand Grassland Association 75: 245-250.

3. Rutledge, S., P. L. Mudge, D. F. Wallace, D. I. Campbell, S. L. Woodward, A. M. Wall, and L. A Schipper. 2014. CO2 emissions following cultivation of a temperate permanent pasture. Agriculture, Ecosystems and Environment 184: 21-33.

Delving into DNA
Part six: Epigenetics

Genetics refers to the study of DNA – the animal's digital code. An animal's DNA sequence (i.e. its recipe) is constant from birth to death and is the same in every cell in the body.

From previous articles

- The DNA code (genetic recipe) is transcribed into a complementary mRNA molecule, which is then translated into an amino acid chain to form a protein.
- We can compare DNA between cows to find changes in the genetic sequence that lead to favourable or unfavourable dairy cow traits. These can then be selected for or against through natural breeding.
- We can also compare the number of mRNA copies of a gene between different herds of cows to determine what effect nutrition or farm management is having at a molecular level. This allows us to predict what can be expected if there is a change in farm management (e.g. cows switched from twice-daily milking to once-a-day milking)

Caroline Walker, DairyNZ Scientist

Different cells perform different functions. This is because the structure of the DNA can be modified, even though the digital code does not change. These structural modifications are called epigenetic changes.

Epigenetics is the reason why a mammary gland cell, for example, does different things compared with a rumen cell – they express different genes because they are structurally different and in a different environment.

There are many different types of epigenetic changes. One of the most widely researched is 'histone modification'. DNA is wrapped around proteins called histones, which contain chemical groups that control how tightly the DNA is wrapped up.

These chemical groups are referred to as epigenetic marks and control access to the DNA recipe (i.e. they turn on or off a gene). Epigenetic marks change in response to the environment and are one reason why different types of cells do different things, why a caterpillar is different to a butterfly even though they have the same DNA, and why identical twins become less alike as they get older.

There are many other types of epigenetic mechanisms that also regulate what a gene does, including DNA methylation, microRNAs and long non-coding RNA.

How does epigenetics work?

Some epigenetic marks cause DNA to be more tightly wrapped around the histone proteins, preventing the gene from producing its protein.

Other epigenetic marks cause DNA to wrap less tightly, allowing better access to the DNA recipe and increasing the amount of protein produced by that gene. In this way, epigenetic modifications can turn off or turn on a gene.

For example, some cancers are the result of epigenetic changes wrapping up the part of the DNA responsible for specialised 'anti-cancer' genes called tumour suppressor genes. In some cases, chemicals that undo these epigenetics marks are used as a cancer treatment.

DairyNZ use of epigenetics

At DairyNZ, we have used epigenetics to determine why some cows are more fertile than others and how changes in feeding or disease regulate changes in gene expression. By studying a particular epigenetic modification called DNA methylation, we have been able to identify an epigenetic mark on a gene that is a master regulator of pregnancy.

This particular modification results in fewer copies of this gene being made in sub-fertile dairy cows and may be one of the reasons why some cows do not get pregnant easily.

Some epigenetic marks are inherited from parents and are very stable, while others are more dynamic and can be changed easily through nutrition or the environment.

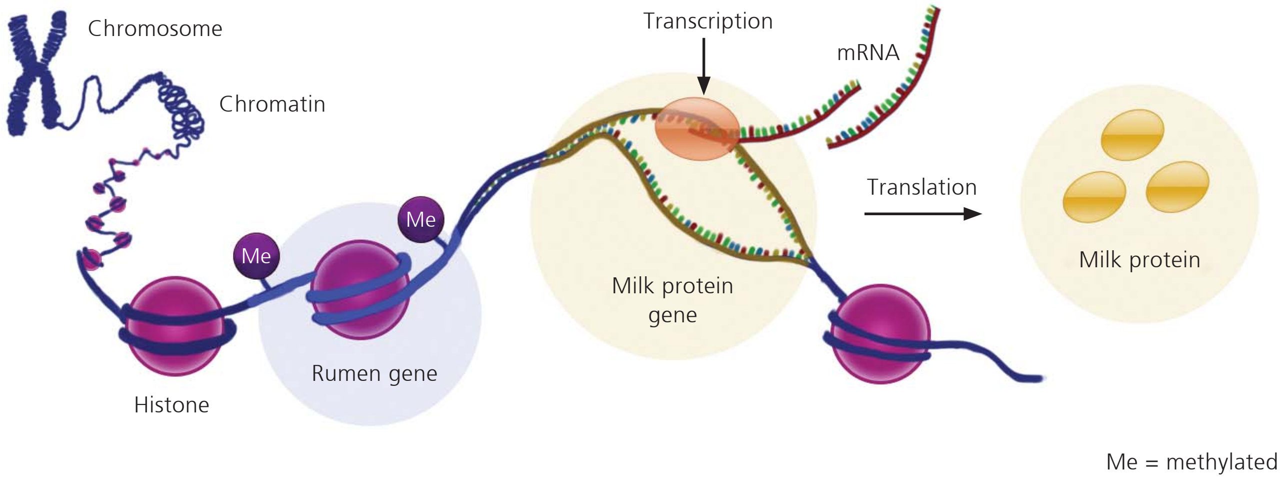
By better understanding the role of epigenetics in how cows respond to environmental or management changes, and through identifying favourable epigenetic signatures, we may be able to incorporate these heritable marks in breeding programmes or we can devise feeding strategies to improve dairy cow function.

Summary

- DairyNZ uses epigenetics to determine why some cows are more fertile than others and how changes in feeding or disease regulate changes in gene expression.
- By better understanding epigenetics, we may be able to incorporate the heritable marks in breeding programmes or feeding strategies to improve dairy cow function.
- Epigenetic marks change in response to the environment and are the reason, for example, why different types of cells do different things.

Epigenetic regulation of mammary cell function.

Epigenetics enables different cells to perform different functions. In this picture the DNA for a gene important in rumen function is wrapped around histone proteins and methylated, therefore no protein is made. The milk protein gene is not wrapped around histones or methylated, enabling it to be transcribed into mRNA and translated into milk protein.



Science snapshots

DairyNZ levy funded or supported science by post-graduate students – our next generation scientists.

Ranking paddock performance using grazing events and milk yield data

(Haultain et al.[1])

- It is important to target the right paddocks for pasture renewal (the poorest performing), but regular farm walks to rank paddock performance are time-consuming.
- Farmers who use milk meters can attribute milk produced to the paddocks grazed and then back-calculate pasture eaten. This shows promise as a quick and simple way of ranking paddocks.
- Integrating such technology with pasture management software could pave the way to 'labour-free' annual paddock assessments.
- Without this technology, simply counting the number of times each paddock is grazed during the season can identify the best and worst paddocks.

CO_2 emissions following cultivation of a temperate permanent pasture

(Rutledge et al.[3])

- Frequent cultivation of cropland often leads to loss of soil carbon. However, little is known about the effect of occasional cultivation during pasture renewal.
- Pastures were cultivated when soil moisture was ample (spring) and limiting (late summer/autumn). Highest soil respiration and carbon losses were recorded in spring.
- To minimise soil carbon losses, minimise the time between spraying the old sward and establishing the new sward or crop. Cultivating when soil moisture is low will also reduce carbon losses (provided soil moisture is sufficient for establishment of the new pasture).

Herbage production from five grazable forages *(Minnee et al.[2])*

- During a two year trial, perennial ryegrass produced more total annual DM than chicory with red clover or plantain, due to better cool season growth and mild weather.
- However, when soil moisture was limiting, chicory with red clover produced 30 percent more DM with superior feed quality compared with perennial ryegrass or plantain. This would likely result in better animal performance.
- Irrigated plantain is an option for increasing summer and autumn feed supply; yielding 0.8 t DM/ha more than irrigated perennial ryegrass in summer.