Balancing multiple objectives in Southland, New Zealand: Performance of dairy cow wintering systems

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Abstract: Practices used to overwinter dairy cows by grazing them on forage crops in New Zealand are coming under increased scrutiny from the populace at large due to potential environmental and animal welfare issues. Farmers in the southern South Island are seeking wintering options that improve the physical and environmental performance of their farms. However, they need to balance a range of objectives for their farms including profitability, labour requirements, effects on the environment, feed supply and quality, animal health and welfare. This paper describes a project involving six commercial dairy farms, each using a different approach to dairy cow wintering: direct-grazed pasture and silage, direct grazing of brassica crops with supplementary feed offered in the paddock, stand-off pads, loose housing with slatted or woodchip flooring and a free stall (cubicle) barn. A range of performance indicators were identified and monitored over a three-year period on each farm. Pasture, supplement and crop yields and quality were assessed and milksolids (MS) production and reproductive performance recorded. Nitrogen (N) losses were estimated using the OVERSEER® nutrient budgeting model. Animal welfare was assessed by body condition scoring (BCS) cows and measuring lying times in the winters of 2011 and 2012. Profitability was assessed by comparing weekly costs per cow during winter. A whole-farm system approach was chosen to assess positive and negative consequences of choices made, and to develop options to improve system performance. Radar charts were used to demonstrate the performance of each farm system against a range of objectives. These charts can be useful when discussing how to balance multiple objectives, helping to avoid unintended negative consequences when changes are based on only one aspect of a system. The monitoring resulted in the development of a wintering risk assessment tool for use by other farmers in the region to benchmark the performance of their wintering system and identify areas for improvement.

Keywords: dairy, wintering, farm system, radar plot

Introduction to the Southern Wintering Systems Initiative

In New Zealand's pasture-based seasonal milk production systems, winter management of dry dairy cows ("wintering") is critical to success. It impacts on milk production, reproductive performance, cow welfare, and growth of young stock (Dalley, 2010). In the southern South Island of New Zealand, low temperatures and high soil water contents reduce pasture growth rates to less than 10 kg DM/ha per day in winter (Dalley & Geddes, 2012) and limit the extent to which pastures can be grazed. Hence, the majority of farmers remove dry cows from the pastures of the milking platform during winter and feed them on support land, mainly on forage crops. This comes at a cost: wintering stock is one of the biggest financial costs of dairying in this region, averaging 20-25% of farm working expenses (Cottier, 2000; Dalley, 2010). Wintering on forage crops is also under increasing scrutiny from the New Zealand public regarding environmental and animal welfare concerns (Dalley, 2011). Consequently, facilities that allow animals to stand off pasture in winter, such as wintering pads, free-stall barns, loose housed barns, 'Off-paddock systems' are becoming more common in southern dairy systems. Regardless of the choice of wintering system, the system must maintain or improve the profitability of the farm business at the same time as achieving environmental, animal or social goals (Riemersma et al., 2007).

This paper describes a whole-farm system approach to assess positive and negative consequences of wintering system choice, and to develop options to improve performance across the range of systems. Based on the results of a farmer survey (Tarbotton et al., 2012) and on-farm monitoring, key performance indicators were developed and incorporated into a wintering risk assessment tool that farmers can use to evaluate the success of their current wintering system. In the survey, winter management was considered critical or highly important by 43% of the interviewed farmers, and 44% considered it important. Farmers were asked on what basis they selected a wintering system. Economic reasons were mentioned by most (39%), followed by control and continuity of the operation and feed supply (21%), fit for their area and soil type (19%), and achievement of better cow condition and health (17%). While 74% rated their level of satisfaction with the current system as high or very high, 39% were willing or very willing to change their system, and 45% had changed their system in the previous five years. The main reasons for change were to protect the environment and soil, reduce cost, and allow better control over feeding and cow condition. Sixty one percent of farmers interviewed cited the cost of capital investment e.g. into barns, wintering pads, support blocks as the main barrier to change.

Bar charts were used to illustrate farm performance relative to industry benchmarks for a range of indicators and radar charts were used to depict tradeoffs between different areas of the system.

Materials and methods

This study was conducted using six commercial dairy farms across Southland and South Otago, New Zealand, between August 2010 and July 2013. These six farms represented a range of wintering systems, the main characteristics of which are reported in Table 1.

Table 1. Characteristics of the monitored farms. Land area (hectares): MP = effective milking platform; SB = support block. Cows: peak number of cows milked in the 2009-2010 season (M) and wintered in 2010 (W). MS: kg milk solids produced in the 2009-2010 season per cow (kg/cow and kg/ha)

Wintering system	Location	Land area	Cows	Milksolids
Loose house barn, slatted concrete floor	Kelso	95 (MP)	275 (M) 300 (W)	478 kg/cow 1383 kg/ha
Self-feed wintering pad	Edendale	110 (MP) 80 (SB)	335 (M) 387 (W)	430 kg/cow 1309 kg/ha
Free stall barn & crop (swedes)	Drummond	120 (MP) 65 (SB)	308 (M) 310 (W)	422 kg/cow 1083 kg/ha
Loose house barn, bark based & crop (kale)	Gore	270 (MP) 160 (SB)	780 (M) 850 (W)	449 kg/cow 1297 kg/ha
Pasture	Mabel Bush/ Castlerock	229 (MP) 252 (SB)	800 (M) 825 (W)	403 kg/cow 1407 kg/ha
Crop (swedes, kale and fodder beet)	Wallacetown	262 (MP, including crops)	730 (M) 803 (W)	388 kg/cow 1081 kg/ha

The monitoring programme used focussed on farm physical and financial performance. Crop yields and supplementary feed inventories were completed prior to winter on all farms to provide information for feed budgeting. Winter feed quality was determined and feed utilisation measured to allow calculation of cow energy intakes during the winter period. The body condition score (BCS, 1-10 scale; DairyNZ, 2012) of all cows was assessed at four times during the season in the following order: pre-calving, pre-mating, early autumn and at drying off. A whole farm nutrient budget was completed using the OVERSEER® Nutrient Budgeting model (Overseer) (Wheeler et al., 2003) version 5.4.8 and the amount and nutrient content of manure and effluent generated in off-paddock systems was assessed. The farm financial accounts were used to calculate the cost of wintering and the cost of winter feed offered in each system. Labour input was assessed from semi-formal interviews with staff and the completion of weekly timesheets during the winter period. A detailed risk assessment was compiled for each farm to identify opportunities for improving wintering performance.

The risk assessment process revealed an opportunity to develop a tool to allow farmers in the region to assess their wintering system performance. The Wintering Risk Assessment Tool was thus developed and piloted with farmers in the region.

Radar charts (Excel 2013) were used to support communication of these results. The radar charts showed how the farms perform against a range of indicators for economic, environmental and physical production aspects of dairying, with each indicator represented by a separate axis starting from the centre of the chart. While radar charts provided visual representation of the trade-offs between different areas of the system they were met with mixed reactions by the monitor farmers and the project reference team. In response to the feedback an alternative method of presenting the results was developed using bar charts.

Results

Table 2. Performance indicators, management rules and targets identified during the analysis of the monitor farm results

System factors	Performance indicator	Management rules and targets
Economics	Winter feed costs (c/kg DM)	Aim for higher yielding crops to reduce c/kg DM by diluting fixed costs associated with growing the crop. Consider feed supply contracts for supplementary feed and complete feed plans early to avoid buying supplement on the spot market.
Economics	Weekly cost per cow ($/cow/wk)	Consider both direct (operating costs) and indirect (depreciation on capital, interest on borrowings etc) costs as systems differ in their level of capital investment.
Control	Feed quantity	Measurement (not estimation) of crop dry matter (DM) percentage for accurate determination of crop yield Ability to source silage of sufficient quality for off-paddock wintering systems.
Control	Feed allocation	Impact of soil type, weather conditions, grazing management and DM allocation on feed utilisation. • Observed crop utilisation range: 60-90% • Silage utilisation in off paddock systems; 90-95%. Attention to detail with crop allocation. Accurate determination of energy requirements to achieve targeted BCS gain. • Feed DM allocation in crop systems was 25% higher than off-paddock systems viz. 14 vs. 11 kg DM/cow/day for a similar BCS gain.
Control	Feed quality	Critical for off-paddock systems where silage is the only source of feed; DM content should be higher than 30%, energy density at least 10.5 MJME/kg DM and crude protein content at least 12% Offering the correct ratio of crop to supplement to prevent metabolic disorders, especially with fodderbeet where at least 30% of the diet should be a forage supplement
Control	Staff annual leave	Systems allowing staff annual leave during winter help ensure staff are refreshed prior to calving
Control	Staff rosters	Rosters should be structured to achieve 40-50 hour working weeks
Cow Welfare	Body condition score at calving	Having 90% of the herd achieve BCS targets at calving of 5 for mature cows and 5.5 for 2 and 3 year olds
Cow Welfare	Lying time	Minimum of 8 hours per day for dry cows Stocking density and bedding surface are major factors influencing lying times in off-paddock systems while weather conditions have a major impact on lying time in grazing systems.
Cow Welfare	Stocking density	Cows should be allocated a minimum loafing area of 1 m^2/100 kg liveweight in off-paddock systems
Cow Welfare	Animal health incidences during winter	All wintering systems should aim to minimise cow deaths (< 1%), lameness (none) and mastitis (<4%) during the dry period.
Environment	Nitrogen loss	Use nutrient budgets to determine N losses from effluent areas and winter crop blocks
Environment	Compliance with regulations	Regional councils have different rules regarding wintering of cows; farmers need to be aware of these and ensure they are achieved at all times

Performance indicators and monitor farm results

Based on the key factors farmers use to choose and assess the performance of their wintering system (Tarbotton et al. 2012) and the results of the monitoring a series of performance indicators were developed (Table 2).

The Southern Wintering Systems Initiative identified four times during the year when whole herd BCS assessments provided information to inform key decisions on the farm. The four times were:

- Pre-mating, to identify at-risk animals that may require intervention
- Early autumn, as part of developing the autumn feed budget
- Prior to drying off, for allocation of animals to mobs for wintering
- Late winter, to determine the success of the wintering system and management in achieving the BCS targets

By identifying individual cows within each BCS range, groups of animals can be tracked and decisions made on the appropriate plan of action. This study highlighted the deficiency of using herd average BCS as a target for assessing wintering system performance. A better metric for assessment is the percentage of the herd less than BCS 5 at calving. This quantifies the number of 'at risk' animals in the herd. For the monitor farms the percentage not achieving BCS 5 at calving ranged from 7 to 41% of the herd.

Lying times in the barn systems were generally less than on crops, pasture and the wintering pad (Table 3), with lying times on crops being weather dependent. Overall the herd averages in all systems achieved the animals' minimum lying requirements of 8 hours per day.

Table 3: Cow lying times for a range of wintering systems in Southland, New Zealand.

	Wintering Systems					
Indicator	**Loose house barn - slatted concrete**	**Wintering pad**	**Free-stall barn**	**Loose house barn - bedding material**	**Pasture & supplement**	**Crops**
Average lying time (h/cow/day)	8.0	11.2	9.2	8.5	11.9	8.1-10.5
Stocking density (m^2/cow)	3.7	12	8	7	>12	>12
Less than 8 h lying (% of cows)	63	0	10	47	0	10

Predictions of nitrogen (N) losses from individual farm blocks on the monitor farms indicated that winter (kale, swedes & fodderbeet) forage crops have a relatively high potential for N leaching losses. Expressed at a whole-system level (i.e. accounting for the milking platform, winter forage crop area and other support land), the winter forage crops accounted for between 11 and 24% of total N leaching losses, despite representing only 4 to 9% of the land area. Off-paddock systems eliminate soil damage in winter but require a good nutrient management plan to minimise the environmental risk. A risk identified for some of these systems was the current practice of applying effluents collected from these facilities to land during winter.

There was considerable variation in the net costs between the farms in the study. The systems with the lowest average net weekly cost per cow utilised direct grazing i.e. crop and pasture (average $25 per cow per week; range $21-$29). This compared with $33 per cow per week (range $29-$40) in off-paddock systems. Feed cost was the most variable, ranging from 12 to 30 c/kg DM offered.

All grass wintering systems were generally considered 'people friendly' utilising similar feed and labour management skills to those used during lactation. Grazed crop systems require sufficient technical knowledge and skill to produce consistently high yielding crops and the work associated with the feeding of this is perceived as hard on people and machinery. In contrast, off-paddock systems appear to have a lower labour requirement compared to other wintering systems and create a more favourable working environment for staff. One issue that needs to be considered is the continuity of the work, i.e. can all tasks be completed in a 2-4 hour block at the beginning of the day or is there a requirement for someone to be around throughout the day to offer more feed?

Wintering risk assessment tool development

The wintering risk assessment tool (Figure 1) was developed to allow farmers in the region to benchmark the performance and identify the risks of their wintering system against the performance indicators that were developed during the project. During the development of the tool, the performance indicators were tested with local farmers and DairyNZ extension staff in the region. A prototype tool was tested at extension events, with feedback incorporated into subsequent versions.

Discussion

This project successfully generated useful data for extension and communication, and for developing and implementing new tools to support farmers in making decisions relating to their wintering system. The development of the "Wintering Risk Assessment Tool" for farmers to assess the risks of their current system provided an opportunity to introduce benchmarks for wintering system performance to more farmers.

Feedback from the local DairyNZ regional extension team following use of the tool with farmers was positive, with the main benefit reported as providing an opportunity to raise issues with the farmer, associated with wintering system performance, which may not be top of mind for the farmer involved e.g. N leaching from the wintering block. The next step of the development was to provide a visual report to the farmer to enable them to develop an action plan to improve their performance. The reporting system was based on bar charts.

Bar charts for reporting risk assessment results

A traffic light system i.e. red (poor performance), orange (average) and green (good performance) bars on a bar chart, provided a visual way for farmers to identify the areas of poor performance for their farm (Figure 2) and develop strategies to address these. Farmers were able to relate to this method of reporting as it is similar to the way they receive their soil test and herbage analysis results.

During the project, important co-learning occurred around the difficulties farmers experienced with each particular system and how this influenced their management decisions. Balancing the welfare of animals and people, environmental outcomes and profitability inevitably led to trade-offs. Radar charts were developed to provide visual representation of the trade-offs between different areas of the system.

Radar charts to identify system tradeoffs

Initially the radar charts were generated by ranking the monitor farms for a range of performance indicators, with the lowest value from the study rated as 25% performance, and the best rated as 100% performance (Figure 3).

The radar charts enabled discussion of the indicators chosen to represent system performance, and illustrated trade-offs: in many cases, improvement in one performance parameter would result in negative effects on another, for example offering more feed to improve cow condition increased feed costs, or measures taken to reduce nitrate leaching would increase net wintering costs.

Depicting system performance this way illustrated the difficulties of balancing multiple objectives, trying to avoid unintended negative consequences that might arise from changing only one aspect of the system. The next phase of the development is to rank individual farm performance on the radar chart against industry-agreed benchmarks for performance indicators.

Evaluation of the radar charts by participating farmers and industry groups was mixed. Some found the charts difficult to interpret, but others had no difficulty and indicated they liked the visual aspect. Presentation of the charts evoked the discussion the project team sought on the choice of indicators, the scale of the axes and the relative weighting and balance of the indicators. Comments from farmers included that "the charts emphasise that there are more areas to target", and that they were "quite a good tool to show this". For other participants (researchers, policy makers, the regional extension team), the charts emphasised the complexity of farm systems, and the challenges farmers face to achieve good performance on all aspects of wintering.

Conclusions

Wintering decisions are complex, making it important to understand the strengths and weaknesses of individual wintering systems. The provision of tools for farmers to assess the performance of their system against industry agreed benchmarks and identify areas for improvement was an important outcome of the Southern Wintering Systems Initiative. Regardless of the wintering system chosen, the system must maintain or improve the profitability of the farm business at the same time as achieving environmental, animal and social goals.

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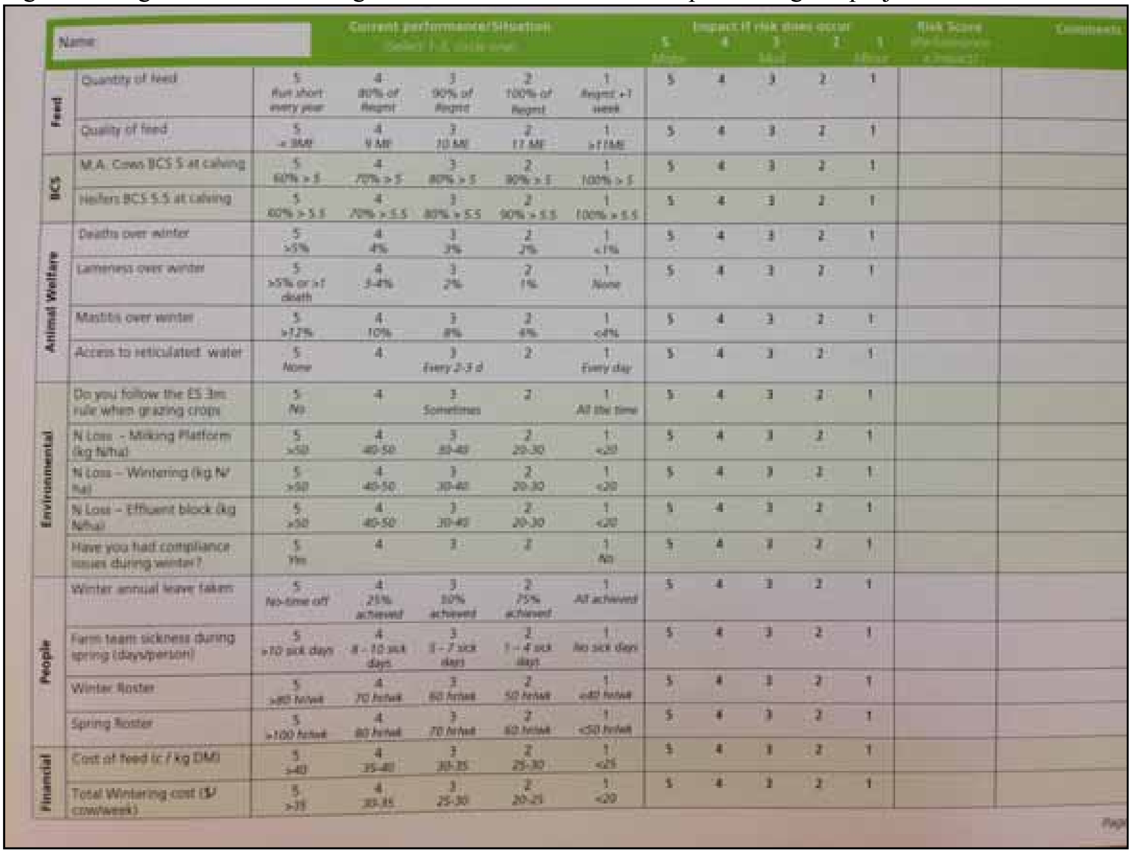
Figure 1: Page 2 of the Wintering Risk Assessment Tool developed during the project



	Name	Current performance/Situation					Impact if risk does occur					Risk Score	Comments
Feed	Quantity of feed	5 Run short every year	4 80% of Reqmt	3 90% of Reqmt	2 100% of Reqmt	1 Reqmt +1 week	5	4	3	2	1		
	Quality of feed	5 < 8ME	4 9 ME	3 10 ME	2 11 ME	1 >11ME	5	4	3	2	1		
BCS	M.A. Cows BCS 5 at calving	5 60% > 5	4 70% > 5	3 80% > 5	2 90% > 5	1 100% > 5	5	4	3	2	1		
	Heifers BCS 5.5 at calving	5 60% > 5.5	4 70% > 5.5	3 80% > 5.5	2 90% > 5.5	1 100% > 5.5	5	4	3	2	1		
Animal Welfare	Deaths over winter	5 >5%	4 4%	3 3%	2 2%	1 <1%	5	4	3	2	1		
	Lameness over winter	5 >5% or >1 death	4 3-4%	3 2%	2 1%	1 None	5	4	3	2	1		
	Mastitis over winter	5 >12%	4 10%	3 8%	2 6%	1 <4%	5	4	3	2	1		
	Access to reticulated water	5 None	4	3 Every 2-3 d	2	1 Every day	5	4	3	2	1		
Environmental	Do you follow the ES 3m rule when grazing crops	5 No	4	3 Sometimes	2	1 All the time	5	4	3	2	1		
	N Loss – Milking Platform (kg N/ha)	5 >50	4 40-50	3 30-40	2 20-30	1 <20	5	4	3	2	1		
	N Loss – Wintering (kg N/ha)	5 >50	4 40-50	3 30-40	2 20-30	1 <20	5	4	3	2	1		
	N Loss – Effluent block (kg N/ha)	5 >50	4 40-50	3 30-40	2 20-30	1 <20	5	4	3	2	1		
	Have you had compliance issues during winter?	5 Yes	4	3	2	1 No	5	4	3	2	1		
People	Winter annual leave taken	5 No time off	4 25% achieved	3 50% achieved	2 75% achieved	1 All achieved	5	4	3	2	1		
	Farm team sickness during spring (days/person)	5 >10 sick days	4 8 - 10 sick days	3 5 - 7 sick days	2 1 - 4 sick days	1 No sick days	5	4	3	2	1		
	Winter Roster	5 >80 hr/wk	4 70 hr/wk	3 60 hr/wk	2 50 hr/wk	1 <40 hr/wk	5	4	3	2	1		
	Spring Roster	5 >100 hr/wk	4 80 hr/wk	3 70 hr/wk	2 60 hr/wk	1 <50 hr/wk	5	4	3	2	1		
Financial	Cost of feed (c / kg DM)	5 >40	4 35-40	3 30-35	2 25-30	1 <25	5	4	3	2	1		
	Total Wintering cost ($/cow/week)	5 >35	4 30-35	3 25-30	2 20-25	1 <20	5	4	3	2	1		

Figure 2. Bar chart depicting wintering risk assessment results from one farm in Southland.

Costs	Results	Optimum	Low	Normal	High
Feed (c/kg DM)	30	25-32			
Feed	**Results**	**Optimum**	Low	Normal	High
Quality (ME)	12	10-13.5			
Quantity	95%	85-95%			
Labour	4	1.5-3			
Kg DM/cow/day	11	11-13.5			
Animal	**Results**	**Optimum**	Low	Normal	High
Animals not adapting	10	10-13.5			
Feed face/cow (mm)	450	350-500			
Mats (mm)	30	25-50			
BCS (% cows ≥ 5)	60	80-100			
BCS (% heifers ≥ 5.5)	80	80-100			
Environment	**Results**	**Optimum**	Low	Normal	High
N loss milking platform					
N loss wintering					
N surplus	125	140-180			
P surplus	73	20			
People	**Results**	**Optimum**	Low	Normal	High
Labour (hours/week)	70	<50			

Figure 3: Radar charts depicting wintering performance of two monitor farms from the Southern Wintering Systems Initiative, winter 2011