
NEW ZEALAND SOCIETY
ANIMAL PRODUCTION
VOLUME 62 2002

Strategically reducing time on pasture: Dairy cow intake, production, welfare, and excretory behaviour

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ABSTRACT

In wet spring conditions, cows are often stood off pasture reducing their pasture intake. However, studies indicate that despite reduced grazing access, pasture intake and milk production can be maintained. This study restricted daily grazing access to eight hours in early lactation to determine the effect on pasture intake, milk production, and urination distribution. Forty-eight Holstein-Friesian cows were allocated to three duplicated treatments. Cows had access to pasture for either four hours after each milking (2x4), eight hours between milkings (1x8), or for 24 hours, excluding milking times (Control). When not grazing, the 2x4 and 1x8 treatments were stood off on a bark pad. The 1x8 cows ate less pasture (10.9 kgDM/cow/d; $P < 0.05$) than the Control (13.6 kgDM/cow/d), but the 2x4 intake (13.0 kgDM/cow/d; $P = 0.46$) was not different to the Control. The 1x8 and 2x4 cows produced less milk (20.2 and 21.5 kg milk/cow/d respectively; $P < 0.05$), relative to the Control (23.3 kg milk/cow/d). Urinations on pasture and races were reduced ($P < 0.05$) from 90% (Control) to 62% (1x8) and 65% (2x4) of total urinations. Eight-hours grazing per day should be offered as two four-hour periods to maintain cow pasture intakes, although milk yields are reduced. Corresponding changes in urination distribution may have environmental benefits.

Keywords: on-off grazing; restricted grazing; excretory behaviour; pasture; dairy; urine.

INTRODUCTION

In Northland, Hauraki Plains and Southland, on-off pasture grazing is used during wet winter/spring conditions to reduce pugging and treading damage, so that pasture production and utilisation is improved (Blackwell, 1993). However, on-off grazing often requires supplements to be fed to maintain cow dry matter intake (DMI) and production, yet grazed pasture is usually the cheapest feed available. When restricting grazing access, strategies should be implemented to ensure that high pasture utilisation and pasture DMI per cow are maintained. Previous studies indicate that opportunities exist to reduce grazing access and maintain pasture DMI and production (Kristensen et al., 2007; Perez-Ramerez et al., 2008; Kennedy et al., 2009). These studies, in mid- to late-lactation, have indicated that cows with restricted access to grazing attempt to compensate for this by increasing their rate of intake. To maintain intakes it was recommended that reduced grazing access should be offered as two grazing periods (Kennedy et al., 2009). The effect of restricted grazing access on unsupplemented cows in early lactation has not been widely studied. Wet spring conditions create a high risk period for nitrogen to be lost by leaching and nitrous oxide (N_2O) emissions from pasture and races (Luo *et al*., 2006). Restricted grazing maybe a strategy that could minimise losses of valuable nutrients at this time, as well as protecting soil and pastures.

The objective of this experiment was to investigate the effect of eight-hour grazing access per day on milk production, pasture intake, animal welfare, and location of urination events from unsupplemented cows in early lactation. The study results will determine if opportunities exist to modify current grazing practices to maintain cow DMI and production, while obtaining environmental benefits from reduced urinations on pasture.

MATERIALS AND METHODS

Animals and treatment descriptions

Forty-eight mixed age primiparous Holstein-Friesian cows (470 kg ± 47 SD; 35 days in milk ± 9) were randomly allocated to one of three treatments with two replicates per treatment (n = 8 cows per replicate). Cows were offered either pasture grazing for four hours after each milking (2x4), eight hours between milkings (1x8), or for 24 hours, excluding milking times (Control). Between grazing periods, the 1x8 and 2x4 cows were stood off on a bark stand-off pad located 1.2 km from the grazing area and 500 m from the dairy. Treatment groups were balanced for calving date, milk yield, milksolids yield and live weight. All animal experimentation was performed following approval by the Ruakura Animal Ethics Committee, Hamilton, New Zealand.

Experimental design and grazing management

The trial was conducted at DairyNZ's Scott Farm, Waikato, New Zealand, in early lactation from late August to early October 2008. The trial protocol included a 16-day adaptation period, followed by a 21-day experimental period, during which data were collected. Cows were grazed on 11 ha of perennial ryegrass dominant pasture. Treatment groups were randomly allocated to neighbouring 833 m^2 plots of pasture daily after morning milking. The Control and 2x4 treatment groups returned to the same plot for their second grazing period after evening milking. Each group was offered the same average daily herbage allowance of 33 kg DM/cow. No supplements were fed. When on the stand-off pad, the cows had an area of 20 m^2/cow. Cows had unlimited access to water on both pasture and the pad. Total rainfall during the experimental period was 33 mm.

Measurements

Pasture measurements

Weekly calibrated visual assessment of pasture was used to develop weekly grazing plans. Pre- and post-grazing heights were measured daily using an electronic rising plate meter (360 mm diameter, 315 g plate weight; Farmworks Fielding; New Zealand). Eighty plate meter measurements were taken from each treatment plot. The equation of:

Pasture mass (kg DM/ha) =
(Pasture height (cm) x 140) + 500

was used to estimate pasture mass from the height measurements (L'Hullier & Thomson, 1988).

Animal measurements

Group pasture intakes were estimated daily from pre- and post-grazing covers (Walters & Evans, 1979; Glassey *et al*,. 1980). Water troughs were fitted with flow meters, which measured daily water intakes on the pasture and stand-off pad for each treatment group. Individual milk yields (kg) were recorded at each milking. Weekly herd tests determined the concentration of milk fat, milk protein, and somatic cell count (SCC; Fossomatic™, Foss Electric, Hillerød, Denmark). Weekly milk samples were analysed for individual cow milk urea nitrogen (MUN) concentration (mmol/L) (Gribbles Veterinary Laboratory, Hamilton, New Zealand). Urinary nitrogen concentration was estimated using the formula:

Urinary nitrogen concentration (mmol/L) = 0.026 x MUN (mg/dL) x live weight (kg)
(Kohn *et al*., 2002).

Live weight and body condition score (BCS), on a scale of 1 (Emaciated) to 10 (Obese) (Macdonald & Roche, 2004), were recorded weekly after morning milking. Locomotion score was measured weekly on a scale of 1 (Normal gait) to 5 (Severely lame) (O'Callaghan, *et al*., 2003). IceTag3D motion sensors (IceRobotics, Scotland) were used to determine the number of steps taken and the corresponding kilometres walked by the cows per day. These devices had previously been validated for use in pasture systems by McGowan *et al.* (2007).

Urination events

Urination sensors (AgResearch Grasslands, Palmerston North, New Zealand) were used to measure the distribution of urinations over 48 hours in two separate weeks of the experiment. These had previously been validated by Betteridge *et al.,* (unpublished data). On average, urination sensor data were obtained from two cows per replicated group. One global positioning system collar was fitted to a cow in each replicated treatment group. These collars monitored the location of the treatment group, which was used to determine the location of urinary events. Urination events were classified as captured on the stand-off pad and dairy yards or uncaptured on pasture and races.

Statistical analysis

The means for each replicate group were calculated using GenStat (Payne *et al*., 2008). ANOVA analysis was used to identify differences between treatment means.

RESULTS

Over the experimental period, each replicate was allocated the same area and daily herbage allowance of 33 kg DM per cow with a mean pre-grazing cover 3191 kg DM/ha ($P = 0.38$). The 1x8 treatment left a greater ($P < 0.05$) post-grazing residual than the Control or 2x4 groups, which were similar (Table 1). The mean calculated pasture intake was less ($P < 0.05$) for the 1x8 treatment than the Control, however, the 2x4 treatment was not different ($P = 0.46$) to either the Control or 1x8 treatment. Mean water intakes were not different across the treatment groups ($P = 0.19$; Table 1).

Milk and milksolids production (kg/cow) were less ($P < 0.05$) for the 1x8 and 2x4 treatments than for the Control treatment. There were no differences in fat (%) or protein (%) across treatments. The treatments had similar $\log_{10}$SCC ($P = 0.15$; Table 1). There were no differences in mean MUN (mmol/L; $P = 0.44$) or estimated urinary nitrogen concentration (mmol/L; $P = 0.89$).

There were no differences in liveweight ($P = 0.77$) or BCS ($P = 0.54$) change across treatments, with all treatments gaining live weight and body condition during the experimental period (Table 1). The 2x4 treatment group walked the greatest distance per day, an average of 1.2 km/cow/day ($P < 0.01$) more than the Control (Table 1). The 1x8 treatment group walked an average of 1.2 km/cow/day ($P < 0.01$) less than the Control, as the

TABLE 1: Pasture, milk production, welfare, and environmental measures from herds grazed for two four-hour periods after each milking (2x4), one eight-hour period between milking (1x8) and at all times other than milking (Control) for 21 days in early lactation. SED = Standard error of difference, MS = Milksolids, SCC = Somatic cell count.

Measurement	Grazing treatment			
	Control	1x8	2x4	SED
Pasture				
Pre-grazing cover (kg DM/ha)	3,243	3,197	3,133	68
Post-grazing cover (kg DM/ha)	1,944^{b}	2,167^{a}	1,943^{b}	33
Pasture intake (kg DM/cow/d)	13.6^{a}	10.9^{b}	13.0^{ab}	0.8
Milk production				
Milk yield (kg/cow/d)	23.3^{a}	20.2^{c}	21.5^{b}	0.4
Milksolid yield (kg MS/cow/d)	1.77^{a}	1.55^{b}	1.59^{b}	0.04
Fat (%)	4.1	4.3	4.1	0.1
Protein (%)	3.5	3.4	3.4	0.1
Welfare				
Liveweight change (kg/cow/week)	3.0	2.8	4.4	0.4
Body condition score change (Unit/cow/week)	0.17	0.20	0.19	0.04
$Log_{10}SCC$	2.0	1.7	2.0	0.1
Locomotion score[1]	1.1	1.2	1.3	0.1
Steps (Number/cow/d)[1]	5,326^{b}	4,029^{c}	6,670^{a}	144
Distance walked (km/cow/d)	4.73^{b}	3.58^{c}	5.93^{a}	0.13
Water intake (L/cow/d)	26.3	21.4	24.3	2.0
Environmental				
Urinations (Number/cow/d)	14.3	12.7	13.8	6.0
Milk urea nitrogen (mmol/L)	7.3	8.2	7.8	0.6
Estimated urinary nitrogen (mmol/L)[2]	85.6	89.1	88.9	8.0
Proportion of urinations on pasture and races[3]	0.90^{a}	0.62^{b}	0.65^{b}	0.07
Proportion of urinations at stand-off pad and dairy[4]	0.10^{b}	0.38^{a}	0.35^{a}	0.07

Different superscripts indicate significantly different means (P <0.05).
[1]Excludes lame cows removed in the first week of experimental period.
[2]Estimated using 0.26 x milk urea nitrogen x live weight (Kohn *et al*., 2002).
[3]Uncaptured urinations.
[4]Captured urinations.

Control cows continued grazing while the 1x8 cows lay on the stand-off pad. In the first week of the experimental period, the 2x4 treatment had a greater (P <0.05) mean locomotion score than the Control and 1x8 treatment. Two cows with locomotion scores of three were removed from the 2x4 treatment on veterinary advice. Two replacement cows were introduced to the 2x4 treatment, to maintain pasture eaten and residuals but were excluded from all measurements. For the remainder of the trial there was no difference in locomotion score across the treatments (P = 0.33; Table 1).

There was no difference in the number of urinations/day across treatment groups (P = 0.97). The proportion of urinations deposited on pasture and races was significantly less (P = 0.05) for the 1x8 and 2x4 treatments, relative to the Control (Table 1). Urinations on pasture were reduced (P <0.05) from 82% (Control) to 51% (1x8) and 45% (2x4) of total urinations. The urinations captured on the stand-off pad and dairy yards for the 1x8 and 2x4 treatments were more than three times that captured for the Control (P = 0.05).

DISCUSSION

Pasture dry matter intake

Restricting cow grazing access to one continuous eight-hour period between morning and afternoon milkings (1x8) resulted in lower DMI than when cows were offered unrestricted grazing access (Control). When grazing was offered as two four-hour periods (2x4), DMI was maintained relative to unrestricted grazing access (Control). By offering the same eight hour total grazing time but in two grazing periods, cows were able to eat an additional 2.1 kgDM/cow/day. In response to the reduced grazing access, cows in the 2x4 and 1x8 treatments attempted to maintain DMI by modifying their grazing behaviour, which is consistent with previous studies (Kristensen *et al*., 2007; Perez-Ramerez *et al*., 2008; Kennedy *et al*., 2009).

Behavioural observations from this trial (Gregorini, 2009) indicate that the 1x8 treatment cows were motivated to eat for a longer proportion of the first four-hour grazing period (81%), compared to the 2x4 (68%) and Control (58%) cows. Kennedy *et al.* (2009) reported similar results when comparing cows with grazing access restricted to a continuous nine-hour period. They found that although the restricted cows grazed for a longer period (81%) relative to the unrestricted cows (41%), DMI was not maintained. However, when this nine-hour period was split into two periods of 4.5 hours, not only were grazing times increased (78%), relative to the Control, but DMI was maintained. In both trials, an increase in time grazing was at the expense of rumination and resting, which could have partially contributed to the reduced DMI. Cows need time to ruminate and process their food in order to maintain their hunger drive (Kennedy *et al.*, 2009). The results of this study confirm that if DMI is to be maintained when grazing access is restricted, cows should be offered two separate grazing periods, allowing for rumination and rest between grazing bouts.

Milk production

The results indicate that milk and milksolids yield cannot be maintained when restricting grazing access to a period of eight hours in early lactation. Treatments did not affect milk fat or protein concentrations. Consequently, the reduced milksolids yield with the 1x8 and 2x4 treatments was due to lower milk yields (Table 1). The 1x8 treatments reduced DMI and milk production, is consistent with the findings of Hutton and Parker (1966) who concluded that, even with abundant pasture cover, it is not possible to graze cows in early lactation for a period of only eight continuous hours and obtain intakes required for peak milk production. However, the results reported here indicate that, when a restricted grazing period of eight hours is offered as two four-hour periods, DMI is maintained. This implies that the 2x4 treatment should theoretically be able to maintain similar production per cow as the Control treatment. This was not the case. The milk yield reduction for the 2x4 treatment can be partially attributed to the additional walking of 1.2 km/cow/d. This has an estimated energy cost of 2.2 MJ ME/cow/d, which could have been used to produce an additional 0.4 kg milk/cow/d (Nicol & Brookes, 2007). If the stand-off facilities had been located closer to the dairy then milk production losses for the 2x4 treatment may have been minimised.

Previous studies found conflicting effects of restricted grazing access on milk production. Kennedy *et al.* (2009) reported that restricting grazing access to a continuous nine-hour period, or two four-and-a-half-hour periods, had no effect on milk yield. Perez-Ramerez *et al.* (2008) and Mattiauda *et al.* (2003) reduced grazing access from eight hours to four hours and found a reduction in milk yield (kg/d) of 5% and 8%, respectively. However, this reduction was due to depressed DMI from only four hours grazing access. These studies all used cows in mid- and late-lactation, with concentrates and supplements offered. The effects of restricted grazing on the unsupplemented dairy cow, especially in early lactation, have not been considered. It has been speculated that unsupplemented cows, with restricted grazing access, will have a greater propensity to graze and will therefore exhibit negligible differences in DMI and milk production. However, in early lactation, this is contingent on cows being able to modify their grazing behaviour, despite peak milk yields and post-calving stresses (Kennedy *et al.*, 2009). The data from this study indicates that when grazing access is restricted to eight hours in early lactation, there are reductions in milk production, despite modified grazing behaviour.

Animal welfare

Over the experimental period, there were no significant differences in liveweight change or body condition score change, with all treatment groups gaining live weight and condition. Despite the additional 1.2 km/cow/d walked by the 2x4 treatment, there was no significant difference in locomotion score across the treatments. In the first week of the trial, two old slow cows were removed from the 2x4 treatment due to lameness. The veterinarian advised that the additional walking during the adaptation period of the trial may have aggravated a pre-existing condition. Cows using stand-off facilities have an increased risk of mastitis, especially in early lactation. Lying on a restricted area of the stand-off surface increases the exposure to environmental pathogens. The provision of adequate cow area and maintenance of the bark surface resulted in no difference in SCC across the treatments.

Urination events

Urination on pasture and races can result in nitrogen losses by nitrate leaching and N_20 emissions. The results of this study indicate that the proportion of urinations located on pasture and races were reduced by nearly a third when grazing access was restricted to eight hours (Table 1). As restricting grazing access did not change the frequency of urinations or mean urinary nitrogen concentration, it is likely that urinary nitrogen losses would have been reduced. In addition, restricting grazing access to eight hours and standing cows off resulted in 38% (1x8) and 35% (2x4) of total urinations being captured, compared with only 10% from cows with unrestricted grazing access. The advantages of this extend to economic gains through lower application of artificial fertiliser. The fertiliser value of dairy shed effluent alone from 100 cows is calculated to be between $1,200 and $1,500 annually (DairyNZ, 2007). Less urine on pasture and increased capture of excreta enables nutrients to be spread more evenly across the pasture, ideally during soil and weather conditions that minimise nitrogen lost by leaching and N_2O emissions from pasture.

CONCLUSION

Provided cows in early lactation are offered eight-hours grazing access as two four-hour periods, pasture intake, and cow welfare can be maintained. However, further work is required to determine whether the impact of eight-hour grazing access on milk production can be minimised. Reducing cow time and urinations on pasture could be a mitigation strategy used to reduce nitrogen losses from grazing pastoral systems. Further investigation into the effects of this strategy on the farm system and economic outcomes is recommended.

ACKNOWLEDGEMENTS

The authors wish to thank DairyNZ Ltd and Sustainable Farming Fund for funding. Urine sensors were developed within the FRST Nitrogen and Taupo programme C10X315. We express our gratitude to Gwyn Verkerk for technical assistance and Barbara Dow for the statistical analysis. Thanks to John Siemelink, the Scott Farm staff, Jennie Burke and DairyNZ Ltd staff who assisted with the trial.

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