Beef cattle wintering systems: effects on cattle and pasture.

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Abstract

The wet winter months are a risk period for damage to pasture under grazing systems in New Zealand. The use of stand-off pads and alternative forages and grazing systems may alleviate these risks, but may also impact on the performance and welfare of cattle. This experiment compared four wintering systems for growing beef calves (9–11 months old, n=103) in terms of growth rate and welfare of calves, and damage to pasture. Treatments were a forage crop of oats, set-stocked grazing on pasture, break-fed on pasture, and break-fed on pasture with use of a concrete feedpad and wood-shavings stand-off area when the soil was wet. Liveweight gain was greatest ($P<0.05$) for the set-stocked (0.81±0.02 kg/day) and break-fed calves (0.52±0.02 kg/day), and least for the calves in the feedpad (0.19±0.02 kg/day) and crop treatments (0.10±0.02 kg/day). The percentage of calves lying down was least in the break-fed and oats treatments ($P<0.05$) but faecal corticosterone concentration was greatest in the feedpad treatment ($P<0.05$). Pasture damage was greater under rotational grazing (score 3.8/5) than set stocking (score 2.9/5), but use of the feedpad did not prevent damage to pasture (score 3.4/5). Set-stocking had the best outcomes for calves and pasture.

Keywords: behaviour; cattle; grazing; pugging; winter

Introduction

Pastoral grazing systems of beef cattle require balancing animal needs with those of the pasture to ensure sustainable, productive livestock systems. Choices that farmers make regarding winter management of cattle and pasture have a significant impact on pasture growth and feed supply in early spring, and on pasture growth in the longer term (Wall et al. 2012). The wet, winter months are a period of increased risk of treading damage to pasture from grazing cattle. A number of wintering strategies have been adopted in the dairy industry to minimise the adverse effects of treading and provide alternatives to pastoral grazing during the risk periods. These include grazing forage crops instead of pasture, and the use of stand-off pads and indoor housing facilities (Dalley 2011).

An ideal wintering system for young beef cattle must allow continued growth of the calves during the winter period, minimise pasture damage, and allow a good standard of animal welfare to be maintained. For example, time spent lying down has been associated with comfort and welfare status in cattle (Miller & Wood-Gush 1991; Fisher et al. 2003), and uncomfortable surfaces such as muddy ground or concrete, have been reported to reduce lying time in dairy cows (Haley et al. 2001).

The susceptibility of soil to damage increases with increasing soil-moisture content (Climo & Richardson 1984). Nie et al. (2001) reported that visual indicators of pugging severity on wet soils provided a good predictor of pasture growth following treading. In addition to reducing subsequent pasture growth, treading damage can reduce pasture utilisation by as much as 40% (Horne & Hooper 1990, Nie et al. 2001).

The aim of this experiment was to compare four different wintering systems for growing beef calves in terms of growth rate and welfare indicators for the calves, and treading damage to the pasture. The systems were: break-feeding on a forage crop of oats, set-stocked on pasture, break-fed on pasture, and break-fed on pasture when soil moisture deficit (SMD) exceeded 2 mm but contained on a feedpad and fed conserved pasture when SMD ≤ 2 mm.

Materials and methods

This experiment was conducted at Massey University's Tuapaka farm near Palmerston North, with approval of the Massey University Animal Ethics Committee. The experimental period was 55 days in duration, and began in mid-June 2013.

Animals

This experiment included 51 steers and 52 heifers aged 9-11 months at the start of the experiment. All animals were Charolais-sired, and dams were Angus, Angus-cross-Friesian, Angus-cross-Jersey or Angus-cross-Kiwicross. Calves had been reared on their dams until a mean of 7 months of age, in two herds based on age and balanced for dam breed-cross and sex of calf. Mean live weight at the start of the experiment was 278 kg (range 190 – 329 kg). Calves were allocated to treatment groups balanced for initial live weight, breed-cross, sex, and rearing herd.

Treatments

Treatments were 'oats', 'set-stocked', 'break-fed' and 'feedpad'. Calves in the oats treatment (n=26) were grazed on 2.61 ha of green-feed black oats (*Avena strigosa*). A fresh grazing area was offered using a break-fence once daily for the first 32 days, then thrice daily (in three smaller breaks) from day 33 to 55 in an attempt to reduce trampling and wastage. Supplementary hay (7.5 MJME/kg DM) was fed at a rate of 0.92 kg DM/animal/day on days 1-32 and 1.84 kg DM/animal/day on days 33-55.

Calves in the set-stocked treatment (n=26) were grazed on pasture at a stocking rate of 3.94 animals/ha. The area was split into two paddocks: 3.90 ha grazed on days 1-25 and 3.21 ha grazed on days 26-55. Pre-grazing pasture mass was 1951 kg DM/ha in the first paddock and 2500 kg DM/ha in the second paddock. The animals were grazed in the first paddock until the pasture cover reached 1100 kg DM/ha. Calves were offered 0.44 kg DM/animal/day of hay throughout the experiment.

Calves in the break-fed treatment (n=26) were break-fed pasture on a total area of 4.33 ha. Calves were allocated a daily break and each break was back-fenced. Break size was calculated based on pre-grazing pasture mass to allow calves to meet their daily feed requirements (Freer et al. 2007) and leave a post-grazing pasture mass of 1500 kg DM/ha. Mean (± SEM) pre-grazing pasture mass was 2719±76 kg DM/ha. Calves were supplemented with 0.46 kg DM/animal/day of hay.

Calves in the feedpad treatment (n=25) were break-fed on pasture or contained on a feedpad depending on the SMD. Soil-moisture deficit was calculated based on the soil-water balance simulation model (Scotter et al. 1979) that considered the long-term average daily evapotranspiration rate (CliFlo 2010). Daily rainfall was measured and put into the model to calculate the SMD at 9 a.m. each day. If SMD > 2 mm then calves were on pasture for the next 24 hours, whereas if SMD ≤ 2 mm then calves were confined to the feedpad for the next 24 hours. The feedpad consisted of a concrete feeding area with a round bale feeder and a resting area lined with wood-shavings. Neither area was covered. Whilst on the feedpad, calves were offered 9 kg DM/animal/day of baleage (12.3 MJME/kg DM), fed as one bale every second day. During grazing, break size was allocated based on pre-grazing pasture mass to allow calves to meet their daily feed requirements (Freer et al. 2007) and leave a post-grazing pasture mass of 1500 kg DM/ha. Mean (±SEM) pre-grazing pasture mass was 2850±147 kg DM/ha. Calves were offered 0.48 kg DM/animal/day of hay, whether at grazing or on the feedpad.

Feed allowance in all treatments was designed to meet the animals' feed requirements at a growth rate of 0.7 kg/day (Freer et al. 2007). Feed allowance exactly equalled requirements, with no allowance for utilisation of feed. Composition of the feeds offered was measured using near infrared spectroscopy on samples collected at the start of the experiment (table 1).

All calves were orally drenched according to individual live weight on days 2, 23 and 44 with Alliance™ triple combination drench (Coopers Animal Health).

Measurements

On days 2 and 55 of the experiment, live weight was recorded after a 17-hour fast. Behavioural observations were made on days 8, 24, 35, 38, 42 and 53. On each of these days, three sequential observations were made for each treatment within a 90-minute period between 1100 and 1630. On each observation, the percentages of calves lying, eating (including those that were drinking) and standing (including those that were walking or riding) without eating were recorded. On day 24 of the experiment, it rained heavily during the behavioural observations and no calves lay down during any observation. These records were excluded from the analysis.

Table 1 Composition of feeds offered in the experiment.

	Pasture[1]	Pasture[2]	Baleage	Oats	Hay
Dry matter (DM)%	12.8	14.1	44.0	8.5	95.5
Crude protein (%DM)	25.1	24.5	9.6	18.7	8.1
Lipid (%DM)	4.2	4.1	1.9	2.3	<1
Ash (%DM)	11.6	10.9	4.7	3.8	6.4
Acid detergent fibre (%DM)	24.6	24.0	35.8	27.8	41.9
Neutral detergent fibre (%DM)	54.6	55.1	53.9	48.1	77.7
Soluble sugars + starch (%DM)	12.0	12.6	9.7	10.2	6.0
Metabolisable energy (MJ/kg DM)	11.9	12.1	12.3	10.9	7.5

[1] Pasture offered to calves in the set-stocked treatment.
[2] Pasture offered to calves in the break-fed or feedpad treatments.

Faecal samples were collected off the ground between 1500 and 1630 hours on days 8, 25, 38, 42, 46 and 53 (after any behavioural observations were complete). On each occasion, a total of 25 faeces per treatment were sampled. Faeces were sampled at random from those that appeared to be fresh. A 20-g sample was taken from each faeces, and these were mixed in groups of five to create five pooled samples per treatment. Samples were stored at -20°C until analysis for corticosterone concentration using the radioimmunoassay method of Morrow et al. (2002). The assay sensitivity was 2.94 ng steroid/g dry faeces. Faecal corticosterone concentration has previously been used to assess welfare of cattle under different housing systems (Starvaggi Cucuzza et al. 2014).

Within the break-fed and feedpad treatments, treading damage of each daily break was scored on a subjective 1-5 scale (1=no damage; 5=severe damage) within seven days of grazing. The second paddock grazed by the calves in the set-stocked treatment was assessed on the same scale at 120 sites at approximately 16 m intervals in a grid pattern within seven days of grazing. In the break-fed treatment, three breaks for each of the damage scores 1, 3 and 5 (a total of nine breaks) were randomly selected and nine chain-reduction measurements were made. A 7.92 m length of chain was laid on the ground and pressed into every indentation on the ground so that it snugly followed the surface in a straight line. The distance between the ends of the chain was measured and the percentage reduction in chain length was calculated as (7.92 – measured length)/7.92 x 100. In addition, 20 randomly selected hoof imprints were selected in each of these nine breaks and the depth of the imprints (from the deepest point of the imprint to the field surface) was measured.

Data handling and statistical analysis

Data analysis was conducted using SAS (version 9.3, SAS Institute Inc., Carey, NC, USA, 2013). Live weight and liveweight gain were analysed using general linear models that included the fixed effects of breed composition, sex and wintering treatment, and the covariate effect of date of birth.

Faecal corticosterone concentration was analysed using a general linear model that included treatment, day of assessment and their interaction as fixed effects. The percentage of calves lying, eating and standing on each day was analysed based on three records per day using a general linear model that included the fixed effects of day and treatment and the interaction between day and treatment.

Hoof-imprint depth and chain-length reduction were analysed using general linear models with pasture-damage score as a fixed effect. Pasture-damage score throughout the experiment for the break-fed and feedpad treatment, and during the period the set-stocked calves were in the second paddock for the break-fed, feedpad and set-stocked treatment, was analysed using a general linear model with treatment as a fixed effect. The scores of the daily breaks were compared with the 120 observations of pasture-damage score throughout the paddock for the set-stocked treatment.

Results

Calves

Liveweight gain was greatest for the set-stocked calves and least for the calves grazed on oats (Table 2). By the end of the experiment, calves in the set-stocked and break-fed treatments were of similar live weight to each other and were 22–36 kg heavier (P<0.05) than calves in the feedpad and oats treatments, which were of similar live weight to each other. Calves in the feedpad treatment spent 56% of their time on the feedpad during the experiment.

Table 2 Least squares means for initial and final fasted live weight (kg) and average daily liveweight gain (kg/day, based on fasted live weight) during the experiment for calves managed in either: a set-stocked or break-fed grazing system on pasture (Set-stocked and Break-fed, respectively), or contained on a feedpad during wet soil conditions and breakfed pasture on remaining days (Feedpad), or breakfed on green-feed oats (Oats).

	Set-stocked	Break-fed	Feedpad	Oats	SEM
n	26	26	25	26	
Initial live weight (kg)	257	263	259	259	4
Final live weight (kg)	300[b]	291[b]	269[a]	264[a]	4
Liveweight gain (kg/day)	0.81[d]	0.52[c]	0.19[b]	0.10[a]	0.02

[abcd] Values within rows without letters in common differ at the P<0.05 level.

Table 3 Least squares means for faecal corticosterone concentration (ng/ml) for each treatment on days 8, 25, 38, 42, 46, 53 and overall. Calves in the feedpad treatment were on the feedpad on days 8 and 25, and on pasture on days 38, 42, 46 and 53. Calves in the set-stocked treatment were moved to the second grazing paddock on day 26.

Day	Set-stocked	Break-fed	Feedpad	Oats	SEM
8	20.05[a]	19.48[a]	31.47[b]	21.95[a]	1.99
25	12.19[a]	20.75[b]	23.02[b]	12.27[a]	1.99
38	16.75[ab]	17.60[ab]	21.96[b]	13.43[a]	1.99
42	20.22[ab]	25.66[b]	21.28[ab]	17.91[a]	1.99
46	21.96[b]	19.17[ab]	17.75[ab]	15.44[a]	1.99
53	18.36[a]	18.68[ab]	25.05[b]	13.67[a]	1.99
Overall	18.25[b]	20.25[b]	23.42[c]	15.78[a]	0.81

[abc] Values within rows without letters in common differ at the P<0.05 level.

Faecal corticosterone concentration fluctuated throughout the experiment for all treatment groups (Table 3), but was notably greatest for the feedpad calves on day 8 of the experiment, at which time the calves had spent their first week on the feedpad. Overall, the calves in the feedpad treatment had the greatest faecal corticosterone concentration (23.42±0.81 ng/ml; P<0.05) and the calves in the oats treatment had the least (15.78±0.81 ng/ml; P<0.05). Feedpad calves were also on the feedpad on day 25 but their corticosterone concentration was similar to that observed at pasture on days 38, 42, 46 and 53. Calves in the set-stocked treatment grazed short pasture on days

25 and 53, but this was not associated with an increase in corticosterone concentration.

There were no differences among treatments in percentage of calves that were lying or standing on the days that feedpad calves were on the feedpad (P>0.05), but fewer calves in the feedpad treatment than in the set-stocked and break-fed treatments were eating on these days (P<0.05, Table 4). Feedpad calves behaved similarly to break-fed calves on the days they were on pasture. Break-fed calves spent more time eating than calves in the oats, feedpad and set-stocked treatments (P<0.05). Calves in the oats and set-stocked treatments had similar non-eating time, but the oats calves spent more of this time standing, whereas the set-stocked calves lay down.

Table 4 Least squares means for percentage of calves lying down, eating and standing for each treatment on days 8, 35, 38, 42 and 53. Calves in the feedpad treatment were on the feedpad on days 8 and 35, and on pasture on days 38, 42 and 53. Calves in the set-stocked treatment were moved to the second grazing paddock on day 26.

Day	Set-stocked	Break-fed	Feedpad	Oats	SEM
Lying					
8	27	18	46	22	12
35	8	17	29	4	12
38	49[b]	6[a]	21[ab]	5[a]	12
42	38	46	40	37	12
53	71[c]	3[a]	9[ab]	40[bc]	12
Overall	38[b]	18[a]	29[ab]	22[a]	6
Eating					
8	51[b]	56[b]	19[a]	42[ab]	11
35	81[b]	67[b]	33[a]	59[ab]	11
38	26[a]	77[c]	71[bc]	41[ab]	11
42	37	42	49	37	11
53	19[a]	92[b]	85[b]	33[a]	11
Overall	43[a]	67[b]	52[a]	43[a]	5
Standing					
8	22	26	35	36	10
35	12	17	37	37	10
38	26[ab]	17[a]	8[a]	54[b]	10
42	24	12	11	26	10
53	10	5	5	27	10
Overall	19[a]	15[a]	19[a]	36[b]	4

[abc] Values within rows without letters in common differ at the P<0.05 level.

Pasture and soils

Hoof-imprint depth was greatest for pasture-damage score 5 (48.6±1.5 mm), intermediate for pasture-damage score 3 (31.9±1.5 mm) and least for pasture-damage score 1 (18.5±1.5 mm; P<0.05). Reduction in chain length increased (P<0.05) with pasture-damage score and was 1.4±0.4%, 3.0±0.4% and 7.8±0.4% for pasture-damage scores 1, 3 and 5, respectively.

Total area grazed during the experiment was 2.57 ha by break-fed calves and 1.78 ha by feedpad calves. Mean pasture-damage score did not differ (P>0.05) between the break-fed and feedpad treatments and was 3.55±0.14 and 3.42±0.20, respectively. During the 28 days that the set-stocked calves were in the second paddock, pasture-damage score was greater for the area grazed by the break-fed and feedpad calves than by the set-stocked calves (3.8±0.2 and 3.4±0.2 versus 2.9±0.1; P<0.05).

Discussion

Growth rate is a key consideration when comparing winter-management options, particularly if it enables calves to reach slaughter weight prior to their second winter. Growth rate of calves differed considerably among treatments so that by the end of the experiment, calves in the set-stocked and break-fed treatments were heavier than calves in the feedpad and oats treatments. In addition, growth rate was greater in the set-stocked compared with break-fed treatment, so that final live weight is likely to have differed between these treatments if a longer period had been considered. Greater liveweight gain of set-stocked than break-fed dairy cows has been reported previously (Judd et al. 1994). Feed allowance was similar for all groups, so differences in growth rate probably reflect large differences in utilisation of available feed, particularly for calves fed oats (Judson & Edwards 2008).

Calves on the feedpad had slower growth than break-fed calves, despite being offered very high-quality baleage. An allowance of 9 kg DM/day of high-quality baleage should have resulted in greater growth rate than that observed for the feedpad calves (Freer et al. 2007). Calves in the feedpad treatment showed elevated corticosterone concentration compared with calves in other treatments when first contained on the feedpad. In addition, fewer calves in the feed pad were eating on that occasion, indicating that the change in diet was contributing to their stress, and likely also to their low liveweight gain.

More calves were standing in the oats treatment than in other treatments, apparently instead of lying down, perhaps indicating an unwillingness to lie down on the muddy, trampled surface. There was no increase in corticosterone despite this change in behaviour; in fact, corticosterone concentration was least in the oats treatment.

Winter can be a time of adverse weather conditions which predisposes land to damage through treading by cattle on saturated soil. This increases nutrient and sediment run-off (Dalley 2011) and also creates an environment that may negatively affect the welfare of the cattle (Stewart et al. 2002). Removing calves from pasture when soil was very moist did not reduce the pasture-damage score compared with breakfeeding calves in this experiment, in agreement with the findings of Houlbrooke et al. (2009), who reported little to no improvement in soil properties from removing cattle from pasture when soil was moist enough to allow pugging. Re-evaluation of the thresholds for grazing may be needed before this strategy can be applied to facilitate protection of pasture from damage.

In conclusion, calves set stocked at a rate of 3.94 calves/ha had superior growth, did less damage to pasture and showed similar or better welfare measures than calves in other treatments, indicating that this was the most suitable management system during winter in this environment. The use of a feedpad in wet weather, or grazing a forage crop of oats resulted in substantially lower growth rates of calves and this was not countered by improvements in welfare or less pasture damage, indicating that improvement of these systems is needed.

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