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## Growth rates of dairy heifers fed alternative feeds

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### Abstract

Dairy heifers need to achieve average daily gains (ADG) that allow them to reach liveweight targets. The aim of this experiment was to measure the effects of grazing 6-month-old dairy heifers on alternative feeds, over the summer period. Sixty 6-month-old Friesian-Jersey crossbred heifers were assigned to one of three treatments (pasture (P), conserved forages (C) or lucerne (L), with all treatments receiving supplementary meal. For the 6-week experiment, feed allowance was based on liveweight gain required to meet liveweight targets. Heifers were weighed at 0, 3 and 6 weeks of the treatment period. Withers height, crown-to-rump length and girth circumference were measured at the start and end of the experiment. L heifers had a greater ( $P < 0.05$ ) average daily gain ( $1.22 \pm 0.03$  kg/day) than P heifers ( $0.57 \pm 0.03$  kg/day), and C heifers were intermediate ( $0.78 \pm 0.03$  kg/day). L and C heifers had a greater ( $P < 0.01$ ) increase in withers height ( $0.15 \pm 0.01$  cm/day and  $0.14 \pm 0.01$  cm/day respectively) than P heifers ( $0.11 \pm 0.01$  cm/day). L heifers had the greatest ( $P < 0.05$ ) increase in girth circumference ( $0.30 \pm 0.02$  cm/day, compared with P and C heifers:  $0.22 \pm 0.02$  cm/day and  $0.16 \pm 0.02$  cm/day respectively). A combined diet of lucerne and meal during drought conditions increased ADG resulting in a greater proportion of heifers reaching liveweight targets.

**Keywords:** heifer; target live weight; lucerne

### Introduction

In New Zealand, dairy heifers at present frequently fall short of recommended liveweight targets (McNaughton et al. 2012). Milk yield in first and subsequent lactations is affected by a heifer's live weight prior to calving (MacDonald et al. 2005; Dobos et al. 2001; van der Waaij et al. 1997) so meeting liveweight targets is critical for subsequent production. McNaughton et al. (2013) identified "herd" (a variable incorporating management factors) as the variable with the greatest effect on the percentage of heifers achieving liveweight targets. The average daily gain (ADG) of heifers during the age periods of 3-6 and 6-9 months of age are frequently not met despite generally meeting 3-month liveweight targets (McNaughton et al. 2012).

The period from 6-9-months of age, for spring-born heifers, coincides with the summer period. Pasture quality declines over the summer period with increased dry matter content of pastures (Litherland et al. 2002). With decreased quality, greater intakes are required to achieve the ADG required to reach liveweight targets. Intakes are limited by the rumen capacity of the heifer (Waghorn 2002). The alternative to increasing intakes is to provide herbage of a higher quality that provides the opportunity for heifers to achieve the required ADG. Therefore use of alternative feeds that have the potential to increase ADG of heifers during the 3-6- and 6-9-months of age periods should be explored.

Lambs grazing mixed-herb swards (plantain, chicory, white- and red-clover) and pure lucerne swards, had greater liveweight gains compared with those grazing pasture by 131% and 65% respectively

(Golding et al. 2011; Burke et al. 2002; Robertson et al. 1995). Examples of alternative feeds to pasture that have shown similar or increased ADG in cattle include pasture silage and brassicas (Muir 2009). Dairy bull calves fed pasture silage achieved ADG of 0.65 kg/day, whereas dairy heifers grazed on a brassica crop achieved ADG of 1.09 kg/day, though there was no comparison with pasture under the same conditions (Muir 2009). Thus these feed sources provide alternatives for grazing heifers to potentially increase ADG during dry summer months.

The aim of this experiment was to determine the effects on growth of feeding alternative forages to 6-month-old dairy heifers over the summer period.

### Materials and Methods

This experiment was conducted with approval from the Massey University Animal Ethics Committee. This experiment was completed at Riverside Farm, near Masterton, latitude -40.50 and longitude 175.37. The experiment was conducted for 6 weeks beginning 5<sup>th</sup> February 2013 (D<sub>0</sub>) during severe drought conditions (Porteous & Mullan, 2013). An acclimatisation period ran from D<sub>-14</sub> to D<sub>-1</sub>.

#### Animals

Sixty Friesian-Jersey crossbred heifers (born spring 2012) balanced for live weight and birth date were assigned to one of three treatments. The initial live weight for all heifers on D<sub>-14</sub> was 137.3 kg (range: 121 kg to 165 kg). The liveweight target for D<sub>-14</sub> was 143 kg and 20% of heifers were at or above this liveweight target on D<sub>-14</sub>.

## Treatments

Heifers were assigned to one of three treatments.

Pasture (P) treatment: P heifers grazed pasture during the period D<sub>-14</sub> to D<sub>41</sub>. Meal was fed at a rate of 1.0 kg heifer/day during the period D<sub>-14</sub> to D<sub>20</sub>, increasing to 1.5 kg meal/heifer/day during D<sub>20</sub> to D<sub>41</sub>.

Lucerne (L) (*Medicago sativa*) treatment: L heifers were acclimatised to grazing lucerne using an on-off grazing system during the period D<sub>-14</sub> to D<sub>0</sub>. L heifers spent 3–4 hours (h)/day grazing lucerne from D<sub>-14</sub> to D<sub>-12</sub>, 6–8 h/day grazing from D<sub>-11</sub> to D<sub>-8</sub> and 10–12 h/day from D<sub>-8</sub> to D<sub>-5</sub>. Time off the lucerne was spent on pasture. From D<sub>-5</sub> to D<sub>41</sub> L heifers spent 24 h/day grazing lucerne. Meal was fed at a rate of 1.0 kg heifer/day during period D<sub>-14</sub> to D<sub>41</sub>.

Conserved forages (C) treatment: due to weather conditions this treatment used a range of feedstuffs including a mixed-herb crop (plantain (*Plantago lanceolata*), chicory (*Cichorium intybus*), white clover (*Trifolium repens*) and red clover (*T. pratense*)), pit pasture silage and pasture baleage. C heifers grazed the mixed-herb crop during the period D<sub>-14</sub> to D<sub>11</sub>, at which time the mixed-herb crop succumbed to the drought conditions and was no longer suitable to be grazed. On D<sub>11</sub> C heifers were removed from herb crop and placed in a heavily grazed paddock with minimal pasture available and fed 3.0 kg DM pasture baleage/heifer/day. On D<sub>21</sub> the 3.0 kg DM pasture baleage/heifer/day was changed to 3.0 kg DM pit pasture silage/heifer/day. Meal was fed at a rate of 1.0 kg/heifer/day from D<sub>-14</sub> to D<sub>14</sub> and at a rate of 1.5 kg heifer/day from D<sub>14</sub> to D<sub>41</sub>.

Meal provided to all consisted of 60% palm kernel expeller (PKE), 20% maize grain and 20% barley grain, with a crude protein (CP) content of 15.5%, a metabolisable energy (ME) of 10.9 MJ ME/kg DM and a dry matter (DM) content of 93%.

## Management

The ADG required to reach 9 months of age liveweight target (40% mature live weight; Troccon 1993) was used to determine dry matter intakes (DMI). For these heifers, the liveweight target at 9 months of age was estimated to be 201.2 kg, and the expected mature live weight was 503 kg. Average daily gains required during the period D<sub>0</sub> to D<sub>41</sub> for the P, C and L treatments were 719, 876 and 869 g/heifer/day respectively. The DMI calculator was sourced from CSIRO's GRAZPLAN<sup>TM</sup> (CSIRO, 2012) and was based on ME of each treatment diet. All treatments were grazed on weekly breaks, determined using herbage available (kg DM/ha/day) and expected herbage growth rates.

Heifers in the C and L treatment groups were dosed with a bloat preventative (Bloatenz Plus®, Ecolab, active ingredient alcohol ethoxylate/propoxylate), via an in-trough dispenser (3 ml/heifer/day). Bloat preventative was not given to C heifers once removed from mixed-herb crop. All heifers were drenched with a triple combination oral

drench based on each individual heifer's liveweight on D<sub>0</sub>, D<sub>20</sub> and D<sub>41</sub> to remove any potential gastrointestinal nematode infection that may affect growth of heifers (Alliance® triple combination drench, Coopers®, active ingredient 2 g/L abamectin, 80 g/L levamisole hydrochloride and 45.3 g/L oxfendazole, with 25mg of cobalt and 5 mg of selenium per 5ml dose) at a dose rate of 1 ml/10 kg live weight + 0.5 ml.

## Animal measurements

Individual live weights were measured on D<sub>-14</sub>, D<sub>0</sub>, D<sub>20</sub> and D<sub>41</sub>. Wither height, crown-to-rump length and girth circumference were recorded on D<sub>-25</sub> and D<sub>41</sub>. Wither height was measured using an adjustable height measuring stick. Crown-to-rump length was measured from the nuchal crest along the spine to the tail until in line with the caudal border of the ischiatic tuberosity, using a tape measure. Girth circumference was measured behind the 13<sup>th</sup> rib, using a tape measure. All measurements were taken while heifers were individually in a weigh crate standing still.

## Pasture measurements

Herbage mass (kg DM/ha) was measured weekly using quadrat cuts (Frame 1993). For all treatments, four quadrats (0.1 m<sup>2</sup>) were cut at ground level from each break, pre- and post-grazing. All herbage samples were washed then dried in a draught force oven for a minimum un-interrupted period of 24 hrs at 70°C (Staff 1961). Mean weights of the four dried quadrat cuts from each break were used to determine the pasture mass.

Weekly hand-grab samples were taken from the pre-grazing breaks for the herbage samples and from supplement fed to the heifers for quality analysis. All samples were analysed using an in vitro digestibility assay analysis (Roughan and Holland, 1977) to measure: in vivo dry matter digestibility content (DMD%), in vivo digestibility of organic matter in dry matter content (DOMD%), in vivo organic matter digestibility (OMD%). Samples were analysed by wet chemistry to measure CP and ash content (Ash%). Samples were analysed by wet chemistry for neutral detergent fibre content (NDF%) and acid detergent fibre content (ADF%) (Van Soest et al. 1981).

## Data handling

The diet quality results for each treatment (Table 3) are accumulative proportions of the wet chemistry and in vitro digestibility analysis results based on predicted dry matter intakes of both meal and forage. Metabolisable energy content (MJ ME/kg DM) of diets was calculated using the equation:

$$ME = 0.16 \times \text{DOMD} \text{ (Geenty et al. 1987)}$$

Liveweight targets were calculated using linear interpolation between industry targets for 6 and 9 months of age. A heifer was considered to be on target if her live weight was equal to or greater than the liveweight target. Change in wither height, change in crown-to-rump length and change in girth

circumference were all calculated by subtracting the initial measurement on D<sub>-25</sub> from final measurement recorded on D<sub>41</sub> with the resulting figure then divided by the number of days between D<sub>-25</sub> and D<sub>41</sub> (67). When age was considered in any calculation a fixed birth date of the 8<sup>th</sup> of August 2012 was used, which was the mean birth date of all heifers in this experiment.

### Statistical analysis

Statistical analyses were conducted using SAS (Version 9.3, SAS Institute Inc, Carey, North Carolina, USA, 2013). Average daily gain, wither height, crown-to-rump length and girth circumference and change in these size parameters were all analysed using linear models. The fixed effect of treatment was included for all linear analyses. Age was considered as a covariate but was not significant for all linear model analysis. Live weight was analysed using a mixed model allowing for repeated measures. The fixed effect of days and treatment and the random effect of heifer were included for mixed model analysis. For mixed model analysis, age was included as a covariate. The variables DMD%, DOMD%, OMD%, CP%, ME, Ash%, NDF% and ADF% were all analysed using linear models with the fixed effects of treatment and day included in each analysis.

### Results

Heifers in all treatment groups had similar initial live weights (Table 1). L heifers grew faster ( $P < 0.05$ ) than C and P heifers so that by D<sub>41</sub> L heifers were 18.1 kg heavier than C heifers and 20.3 kg heavier than P heifers. All treatments had a similar number of heifers at or above liveweight target on D<sub>0</sub> (Table 1). A greater proportion of L heifers were at or above liveweight target by D<sub>41</sub> than P or C heifers (Table 1).

L heifers had a greater ( $P < 0.01$ ) change in girth circumference D<sub>-25</sub> – 41 compared to P or C heifers (Table 2). There were no difference in crown-to-rump length and change in crown-to-rump length (Table 2). L heifers had a greater ( $P < 0.01$ ) change in wither height D<sub>-25</sub> – 41, than the P heifers with C heifers being intermediate (Table 2).

The diet of the L treatment had a greater ( $P < 0.05$ ) CP% and ADF% than either the diets of P and C treatments (Table 3). The diet of the L treatment had a greater ( $P < 0.05$ ) ME, NDF%, *in vivo* DOMD% and *in vivo* OMD% content than the diet of P treatment, with the diet of C treatment being intermediate (Table 3). The diet of the L and C treatments had a greater ( $P < 0.05$ ) *in vivo* DMD% than the diet of the P treatment (Table 3).

**Table 1** The effects of dietary treatment on the growth performance of dairy heifers. Values are least squares means  $\pm$  SE.

Measurement	Pasture	Conserved Forages	Lucerne	Liveweight target <sup>1</sup>
n	20	20	20	
Initial live weight (kg)				
D <sub>-14</sub>	137.5 $\pm$ 2.4	136.8 $\pm$ 2.4	137.5 $\pm$ 2.4	143.2
Live weight (kg)				
D <sub>0</sub>	143.8 $\pm$ 2.6	137.2 $\pm$ 2.6	137.5 $\pm$ 2.6	150.9
D <sub>20</sub>	158.7 $\pm$ 2.9	161.2 $\pm$ 2.9	160.5 $\pm$ 2.9	162.5
D <sub>41</sub>	167.9 $\pm$ 3.3 <sup>a</sup>	170.1 $\pm$ 3.3 <sup>a</sup>	188.6 $\pm$ 3.3 <sup>b</sup>	174.0
Average Daily Gain (kg/day)				
D <sub>0-20</sub>	0.71 $\pm$ 0.04 <sup>a</sup>	1.14 $\pm$ 0.04 <sup>b</sup>	1.10 $\pm$ 0.04 <sup>b</sup>	
D <sub>20-41</sub>	0.44 $\pm$ 0.05 <sup>a</sup>	0.42 $\pm$ 0.05 <sup>a</sup>	1.34 $\pm$ 0.05 <sup>b</sup>	
D <sub>0-41</sub>	0.57 $\pm$ 0.03 <sup>a</sup>	0.78 $\pm$ 0.03 <sup>b</sup>	1.22 $\pm$ 0.03 <sup>c</sup>	
Proportion of heifers reached target <sup>2</sup>				
D <sub>-14</sub>	20% (4/20)	15% (3/20)	25% (5/20)	
D <sub>0</sub>	20% (4/20)	15% (3/20)	20% (4/20)	
D <sub>20</sub>	35% (7/20)	35% (6/20)	40% (8/20)	
D <sub>41</sub>	30% (6/20)	20% (4/20)	85% (17/20)	

<sup>abc</sup> Values within rows with different superscripts are significantly different ( $P < 0.01$ ).

<sup>1</sup> Liveweight targets were calculated by linear interpolation between industry targets for 6 to 9 months of age.

<sup>2</sup> This is the proportion of heifers in each treatment that were at or above the target live weight on each date.

**Table 2.** Initial measurements (D<sub>-25</sub>) for girth circumference, crown-to-rump length and wither height, and change in these parameters during the experiment (D<sub>-25</sub> to D<sub>41</sub>) of 6-month-old dairy heifers. Values are least squares means  $\pm$  S.E.

Measurement	Pasture	Conserved Forages	Lucerne
Girth circumference (cm)	145.9 $\pm$ 1.3	143.5 $\pm$ 1.3	144.6 $\pm$ 1.3
Change in girth circumference (cm/day)	0.22 $\pm$ 0.02 <sup>a</sup>	0.16 $\pm$ 0.02 <sup>a</sup>	0.30 $\pm$ 0.02 <sup>b</sup>
Crown-to-Rump length (cm)	127.0 $\pm$ 1.4	128.4 $\pm$ 1.4	128.8 $\pm$ 1.4
Change in Crown-to-Rump length (cm/day)	0.02 $\pm$ 0.03	0.02 $\pm$ 0.03	0.05 $\pm$ 0.03
Wither height (cm)	93.9 $\pm$ 0.6	94.6 $\pm$ 0.6	94.8 $\pm$ 0.6
Change in wither height (cm/day)	0.11 $\pm$ 0.01 <sup>a</sup>	0.14 $\pm$ 0.01 <sup>ab</sup>	0.15 $\pm$ 0.01 <sup>b</sup>

<sup>abc</sup>Values within rows with different superscripts are significantly different (P < 0.05).

**Table 3** Results from wet chemistry and *in vitro* digestibility analysis of hand-grab samples for complete diets of three treatments measuring: crude protein % (CP%), neutral detergent fibre % (NDF%), acid detergent fibre % (ADF%), *in vivo* dry matter digestibility (DMD), *in vivo* digestibility of organic matter in dry matter (DOMD), *in vivo* organic matter digestibility (OMD) and ash %. Values are least squares means  $\pm$  SE.

Measurement	Pasture	Conserved Forages	Lucerne
CP%	14.00 $\pm$ 1.10 <sup>a</sup>	17.35 $\pm$ 1.10 <sup>a</sup>	22.93 $\pm$ 1.10 <sup>b</sup>
ME	9.97 $\pm$ 0.14 <sup>a</sup>	10.53 $\pm$ 0.14 <sup>b</sup>	11.08 $\pm$ 0.14 <sup>c</sup>
NDF %	48.96 $\pm$ 2.39 <sup>c</sup>	40.66 $\pm$ 2.39 <sup>b</sup>	31.25 $\pm$ 2.39 <sup>a</sup>
ADF %	26.13 $\pm$ 1.11 <sup>b</sup>	22.88 $\pm$ 1.11 <sup>b</sup>	18.21 $\pm$ 1.11 <sup>a</sup>
<i>In vivo</i> DMD	66.80 $\pm$ 1.01 <sup>a</sup>	70.26 $\pm$ 1.01 <sup>b</sup>	73.28 $\pm$ 1.0 <sup>b</sup>
<i>In vivo</i> DOMD	62.28 $\pm$ 0.89 <sup>a</sup>	65.79 $\pm$ 0.89 <sup>b</sup>	69.23 $\pm$ 0.89 <sup>c</sup>
<i>In vivo</i> OMD	68.51 $\pm$ 1.99 <sup>a</sup>	72.56 $\pm$ 1.99 <sup>b</sup>	76.61 $\pm$ 1.99 <sup>c</sup>
Ash %	6.86 $\pm$ 0.61	6.92 $\pm$ 0.61	7.98 $\pm$ 0.61

<sup>abc</sup>Values within rows with different superscripts are significantly different (P < 0.05).

## Discussion

Feeding heifers a combined diet of lucerne and meal demonstrated that this diet can be used to accelerate growth of heifers during the dry summer period. Feeding a combined diet of conserved forages and meal resulted in greater liveweight gain than grazing on poor quality pasture with supplementary meal. To the authors knowledge the ADG of six-month-old dairy heifers grazing lucerne has not previously been published in New Zealand.

The ADG for L heifers was 114% greater than that seen in P heifers. This is more than the 65% greater in ADG of lambs grazed on lucerne compared to lambs grazed on pasture (Golding et al. 2011; Burke et al. 2002). The diet of the L heifers had a greater ME, CP% and digestibility compared to both the C and P heifer diets, which would contribute to the greater ADG in the L heifers. The greater digestibility of the L

diet would increase the rumen outflow of the L heifers which would lead to a greater intake by the L heifers leading to a greater amount of energy and protein available for growth (Orskov et al. 1988). With the addition of the meal, a greater amount of ME is available to capture excess CP provided by the lucerne which is important for growth, particularly muscle deposition (Webster 1993).

Despite the experiment being short-term, treatment effects were observed in the change in girth circumference and height. L heifers had a greater change in girth circumference than either P or C heifers. L heifers also had a greater change in height than P heifers. Given that the absolute change in these parameters was 0.02 to 0.30 cm/day, it is likely that heifers would need to be grazed on these feeds for a longer period to determine if there are greater effects than those seen in this experiment.

The heifers used in this experiment were below the 6-month of age liveweight target at the start of the experiment (Table 1). Throughout the experiment an average live weight was used for each treatment group to calculate the required ADG to reach liveweight targets. Each treatment group included heifers that had a range of live weights, both above and below liveweight target. The results presented here demonstrate that by accepting that the average of a mob has reached the liveweight target there is always going to be some heifers that fail to reach the liveweight target. Assessing each heifer's live weight on an individual basis allows for those below liveweight target to be preferentially fed. Dry matter intakes estimated from pre- and post-grazing cuts (data not presented) showed sufficient dry matter offered to meet ADG required for all treatments based on the predicted DMI calculated. It is possible that the DMI calculator under-estimated the DMI intakes required for the P and C treatments based on the fact that P and C heifers did not achieve the required ADG needed to reach liveweight targets. A possible contributing factor to this could be that the herbage quality was less than the values used in the DMI calculator. The required DMI calculated was greater than the industry recommendations (DairyNZ 2012). As the heifers were below liveweight targets, the calculated ADG would have to be greater than industry recommendations to allow heifers to reach liveweight targets.

Lucerne with the addition of supplementary meal was a suitable alternative feed source for dairy heifers enabling target growth rates to be achieved. The mix of herbages used in the conserved forage treatment was also shown to be a suitable alternative to dry summer pasture. Both dry summer pasture and the mix of conserved forages did not allow heifers to grow sufficiently to meet liveweight targets.

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