Pasture utilisation in a pastoral automated milking system

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Abstract
Over the past 5 years a herd of up to 180 cows has been milked by two automated milking systems (AMS) at the Greenfield Project research farm near Hamilton. The performance parameters pertaining to pasture management and pasture utilisation during the 2004/05 season are described. The 54 ha farm had an estimated net pasture accumulation of 16.2 t DM/ha/yr. The estimated pasture consumption was determined using back calculations to be 12.3 t DM/ha/yr resulting in an estimated efficiency of pasture utilisation of 76% (based on consumed vs. net accumulation). The data presented suggest that it is possible to achieve satisfactory pasture intakes, pasture utilisation and to be able to maintain pasture quality with automatic milking in a low-input, pasture-based system.

Keywords: automatic milking, grazing, pasture management, pasture utilisation

Introduction
In New Zealand dairying there is a trend towards larger farms with larger herds and a changing farm ownership structure resulting in more reliance on employed labour (Tipplese et al. 2004; LIC Stats 2005). When combined with a declining labour pool and the work and lifestyle constraints imposed by fixed-time milk harvesting, this gives rise to a sustainability issue for the New Zealand dairy industry. At the 2001 census, 26,331 people were employed as dairy farmers/dairy farm workers, most of whom are required to milk approximately 4 million cows as part of their daily routine. Data from the 2004/05 Economic Farm Survey show that, on average, 8.0% of total feed is brought in as supplement with a further 5% sourced from crop, hay or maize grown on farm, indicating that New Zealand farms are still predominantly pasture-based.

For automatic milking to be considered a viable option in the NZ dairy industry it is imperative that the system can accommodate low levels of bought in feed and high levels of pasture utilisation. Since 2001 pastured cows have been milked in a voluntary and distributed (throughout each 24 hour period rather than batch milked) manner initially through one and now two automatic milking units at Dexcel’s Greenfield Farm, Hamilton. The objective of the 2004/05 season on the Greenfield research farm was to determine the key performance indicators, of which pasture management was a major focus. During this period, the farm and herd size were held stable after 3 years of development and size increases. This paper describes the performance parameters pertaining to pasture management, pasture utilisation and pasture quality. The practical feasibility, focussing on cows ability to learn to milk voluntarily (Jago et al. 2004; Woolford et al. 2004) and the projected economic viability (Jago et al. 2006), of the Greenfield farm have been reported elsewhere.

Methods
Data were collected throughout the 2004/05 production season (1 June 2004 – 31 May 2005). The total herd size peaked at 179 (mixed age, mixed breed; Fr, J and FrxJ) cows, 30 of which calved in autumn 2004 and the remainder in spring 2004. All cows were mated in late 2005 to provide a seasonal spring calving pattern for 2005/06 with no autumn calving cows.
Pasture management and farm configuration
The farm had a milking platform of 43 ha and a run-off of 11 ha that was used as a dry cow/young stock grazing area. The farm configuration was such that non-lactating stock were able to graze on the milking platform but milking stock were not able to graze the run-off area. The milking platform (Fig. 1) consisted of four blocks of pasture (ranging from 9.2 to 12.7 ha) with limited or no internal fencing. A rotational grazing system was used, based on strip grazing of each block using temporary and back fencing. However, on occasions cow traffic and/or pasture allowances resulted in undesirably high post-grazing residuals. In these instances the size of the next strip was reduced with no back fence to allow cows to regraze the high residual strip.

The farm had a total annual application of 213 kg N/ha/yr (five applications in the form of urea). Potash was applied to the whole farm at a rate of 177 kg/ha in October and a fertiliser blend (89.91% Super Ten, 6.99% Calmag, 3.00% Durasul Sulphur and 0.1% Selenium Ultra) was applied in March/April 2005 at a rate of 670 kg/ha.

The system hardware consisted of a selection unit (SU) made of a concrete base and pipe rails, allocated to each of the four blocks of pasture (Jago et al. 2002; Jago et al. 2004). The grazing system used two areas of pasture, one on the day side and one on the night side of a block at any one time. On presentation at the exit gates of the SU, a cow was either directed along the race to the dairy for milking, or released to pasture, via computer-controlled gates. The SU were used to restrict access to
the AMS based on expected yield and production rate criteria set within the AMS software. The herd had a targeted average milking interval of approximately 18.5 h in keeping with maximising milk output by having a high ratio of cows to AMS (90 cows/AMS compared to commonly reported 30-60 cows/AMS). The direction of cow traffic (to day-side or to night-side) was reversed twice every 24 h at 8:00 h and 20:00 h. At 08:00 h any cows that had not voluntarily moved out of the paddock on the day side were moved into the SU while cows returning from the AMS, or diverted “to paddock” when exiting the SU, began to enter a new area of pasture on the day side. Similarly, at 16:00 h, any cows remaining on the night side were moved to the SU and, from 20:00 h onwards, cows returning from the AMS or diverted “to paddock” when exiting the SU began to enter a new area of pasture on the night side.

**Pasture data collection**

Pasture mass was estimated by visual assessment on a weekly basis. Estimated net herbage accumulation was calculated weekly from the increase in pasture mass on ungrazed paddocks.

Pasture chemical composition was not assessed in the 2004/05 season. From November 2005 to March 2006, pasture samples were collected monthly by hand clipping to grazing height from areas about to be grazed. These were oven dried at 60°C, ground and analysed for chemical composition by NIRS (Ulyatt et al. 1995).

**Pasture intake calculations**

Estimated pasture consumption was determined using back calculations (sourced from I. Brooks, Massey University and P. Hedley, Dexcel Ltd). Calculations were based on an estimated average cow liveweight (LWT) of 455 kg. The herd was 60% Friesian (Fr), 12% Friesian x Jersey (FrxJ) and 20% Jersey (J). The milk production level was calculated using kg milk recorded by the AMS software (Crystal® 1.40, Fullwood Fusion, Holland) and average percent milksolids recorded by the factory. There were also 12 rising 1-year-old heifers and 12 rising 2-year-olds grazed on the dry cow/young stock area. The equations used were as follows:

- **Maintenance** = \((LWT^{0.75}) \times 0.483 \times DIM \times (((11 - Ave MJ ME of feed offered)/1) \times 0.286) + 1)\)
- **Pregnancy Requirements** = 2222 MJ ME (Fr), 1947 MJ ME (FrxJ), 1672 MJ ME (J).
- **Milk Production** = \((Total \ MS \times (68 \ Fr; 67 \ FrxJ; 65 \ J) \times 1.1) \times (((11 - Ave MJ ME of feed offered)/1) \times 0.0334) + 1)\)
- **Walking Energy** = \(((Ave \ distance \ walked \ per \ day \times 0.0036 \ \times \ cow \ LWT) + \ (average \ vertical \ height \ between \ farm \ dairy \ and \ hill \ paddocks \ in \ metres/1000 \ \times \ cow \ LWT \times 0.039)) \times (((11.0 - the \ Ave \ MJ \ ME \ of \ feed \ offered)/1) \times 0.0286) + 1) \times (0.6 \ for \ milking \ frequency \ of \ 1.17) \times DIM/cow.

Total energy per cow including cost of grazing = (Maintenance + Pregnancy + Milk Production + Walking Energy) * (1 + (0.038 * (1 + ((11.0 – the ave MJ ME of feed offered) * 0.14)))).

(Abbreviations: Ave = average, LWT = liveweight, MJ ME = megajoules of metabolisable energy, Fr = Friesian, J = Jersey).

**Results**

The 54 ha farm had a net pasture accumulation of 16,187 kg DM/ha/yr (Fig. 2, total 874.1 t DM/yr). In addition there was 24.4 t DM bought onto the farm in the form of crushed barley/wheat, resulting in a total feed availability of 898.5 t DM. Grazing rotations ranged from 113 days in winter to 14 days through early November 2004. Surplus pasture was harvested as baled and pit silage

![Figure 2](image-url)
and was fed back to the cows during periods of pasture deficit. The net accumulation of supplements from 1 June 2004 to 31 May 2005 was zero. No topping was carried out.

The estimated annual energy consumption was 7,278,904 MJ ME. Four percent of this was provided in the form of crushed wheat/barley fed in the bail during milking (24.4 t DM x 12.5 MJ ME/kg DM). Assuming an average metabolisable energy for pasture of 11.0 MJ ME/kg DM, the estimated pasture consumption level was 12,272 kg DM/ha/yr. Expressed as a proportion of the estimated net pasture accumulated, the pasture utilisation rate was 76%.

Pasture quality measurements (taken in the 2005/06 season) indicated this was adequate for milking cows, with average ME levels of 11.3 MJ/kg DM, average crude protein of 20.4% of DM, and average organic matter digestibility of 75.6%. Acid detergent fibre and neutral detergent fibre averaged 26.3% and 53.9%, respectively.

Table 1 details the stocking rate and milk and pasture production/utilisation during the 2004/05 season. Whilst the targeted average milking interval was 18.5 h (1.3 milkings/cow/day), the actual annual average milking interval was 20.8 h (1.1 milkings/cow/day). The proportion of the herd that remained in the paddock at 08:00 h (end of day paddock grazing allocation) or 16:00 h (end of night paddock grazing allocation) and had to be moved out ranged from 12-22% from July to December. This changed markedly after that period with a lower proportion of the herd requiring manual movement following the daytime grazing than following the overnight grazing (Fig. 3).

**Discussion**

Automating milking in a pastoral dairying system is a new concept that presents many challenges to traditional farming methods. Current dairy farm systems in New Zealand have been designed to accommodate the needs of cattle grazed on grassland systems. This new technology has the potential to increase productivity through better use of feed resources and higher milk production.

**Table 1** Stocking rate, average lactation length, average milk production, estimated net herbage accumulation and pasture consumption levels for season 2004/05 on the Greenfield farm.

<table>
<thead>
<tr>
<th>Stocking rate (cows/ha)</th>
<th>3.31</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comparative stocking rate (kg LWT/t DM)</td>
<td>96.5</td>
</tr>
<tr>
<td>Average lactation length (days)</td>
<td>274</td>
</tr>
<tr>
<td>Average annual milk production (kg MS/cow)</td>
<td>281</td>
</tr>
<tr>
<td>Average annual milk production (kg MS/ha, all)</td>
<td>936</td>
</tr>
<tr>
<td>Average annual milk production (kg MS/ha milking platform only)</td>
<td>1170</td>
</tr>
<tr>
<td>Net herbage accumulation (kg DM/ha/year)</td>
<td>16187</td>
</tr>
<tr>
<td>Pasture consumption (kg DM/ha/yr)</td>
<td>12272</td>
</tr>
<tr>
<td>Pasture consumption (MJ ME/ha/yr)</td>
<td>140637</td>
</tr>
<tr>
<td>Pasture consumption (MJ ME/cow/yr)</td>
<td>40484</td>
</tr>
</tbody>
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Figure 3 Monthly average proportion of milking herd manually moved off the break at the end of the allocated grazing period at 08:00h and 16:00h for 2004/05 season on the Greenfield farm.
Zealand are based upon high levels of pasture utilisation and maintaining pasture quality. The efficiency of pasture utilisation of 0.76 reported here is comparable with 0.70 and 0.72 for farmlets stocked at 76 and 90 kg LWT/t DM, respectively (Macdonald et al. 2001). This indicates that voluntary movement on the automated milking farm does not appear to have negatively compromised the efficiency of pasture utilisation, although the higher stocking rate for the Greenfield farm may have assisted in achieving this result. Pasture quality, in the year after pasture utilisation efficiency was estimated, was at the lower end of that reported by Macdonald et al. (2001) for farmlets of increasing target stocking rate, although it is still considered to be of an acceptable level. The fact that no topping was required also indicates that pasture quality was able to be managed through grazing pressure.

An essential element of a 24 h milking system is achieving distributed and voluntary movement of cows from the pasture area to the dairy. There are many factors that affect the level of voluntary movement, including stage of lactation (Jago et al. 2006), climatic conditions, individual cow experience (J. Jago, unpublished data), location and timing of availability of feed (Jago et al. 2004) and water incentives in the system and pasture allowance. Whilst it is difficult to quantify the impact of pasture allowance on cow movement patterns, it has been observed that a low pasture allowance generally results in fewer cows requiring manual movement from allocated grazing areas than when grazing a higher pasture allowance. While the goal is not to have to manually move any cows from the pasture area following a grazing allocation, the time required to do this was not great since it was done at the same time as gates were changed to control the direction of cow flow to fresh grass.

One of the key approaches to incorporating automatic milking technology within low input pastoral systems is to maximise milk output by increasing the ratio of cows per AMS above those typical for international AMS operations. To minimise per cow production losses known to result from extended milking intervals such as once daily milking (Clark et al. 2006), the targeted average milking interval for the Greenfield herd was approximately 18 hours (with an average milking frequency of 1.3 milkings/cow/day). The actual average milking frequency ranged from 17.4 to 23.5 h on a monthly basis with an overall annual average interval of 20.8 h (1.1 milkings/cow/day). The level of per cow production (281 kg MS/ha) was 12% higher than the 4-year average production levels reported by Clark et al. (2006) for Friesian cows milked once-a-day (252 kg MS/cow) reflecting the 20.8 h average milking interval. Similarly, production of 936 kg MS/ha (1176 kg MS/ effective ha) was slightly higher than the 882 kg MS/ha reported for the once-a-day milking trial. Improving production performance will require a shorter milking interval than achieved in the 2004/05 season. A greater understanding of the interactions between pasture availability, time since last milking and cow movement patterns is required.

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