DRY MATTER INTAKE OF DAIRY COWS GRAZING IRRIGATED PERENNIAL PASTURES ESTIMATED BY THREE METHODS.

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SUMMARY

Dry matter intake of dairy cows grazing pasture based on perennial ryegrass (*Lolium perenne* L.) pasture at low or high herbage allowances was estimated from pre- and post-grazing pasture masses (PMM), using *n*-alkanes or by calculations based on cow performance and published estimates of energy requirements (PERM). Pasture intakes were lower (14.1 vs 17.1 kg DM/day) ($p<0.05$) at low compared to high herbage allowance when estimated using PMM, PERM and C_{31}/C_{32} alkanes. When C_{33}/C_{32} alkanes were used, there was no difference in intake between the 2 allowances (18.5 vs 18.6 kg DM/day). The estimates of intake using *n*-alkanes were higher ($p<0.05$) than for PMM or PERM. Sources of error and uncertainty with each method are discussed.

Keywords: alkanes, pasture mass, pasture intake

INTRODUCTION

Pasture intake of grazing dairy cows is affected by pasture allowance (Wales *et al.* 1998). Within a herd, the time spent grazing, bite size and behavioural interactions between cows affect intake and performance of individual animals. Measurements of pre- and post-grazing pasture mass (referred to as pasture mass method, PMM) are regularly used to estimate pasture consumed by groups of cows, but this gives no indication of the variation in intake between individuals within a herd.

Dosed and herbage *n*-alkanes can be used as markers to estimate intake of individual animals fed in pens or at grazing (Dove and Mayes 1991). In experiments with grazing cows fed supplements, estimates of DM intake obtained from PMM and *n*-alkanes have corresponded for some treatments, but in many instances have been quite different (Reeves *et al.* 1996; Robaina *et al.* 1998).

This paper compares the intakes of groups of cows grazing irrigated pastures based on perennial ryegrass (*Lolium perenne* L.) using PMM or *n*-alkanes. A third estimate of intake was calculated (referred to as PERM) from measurements of cow performance and published estimates of energy requirements (SCA 1990).

MATERIALS AND METHODS

The treatments were low and high (19 vs 38 kg DM/cow/day) herbage allowances for cows strip grazing irrigated perennial ryegrass/white clover (*Trifolium repens* L.) pasture. The 2 treatments were replicated 3 times with 3 non-pregnant cows per replicate of which 1 had a rumen fistula. The methods for pasture allocation and assessing the amount of pasture eaten by each group between days 31 and 38 of the experiment using PMM have been described by Wales *et al.* (2001). Each day between 50 and 100 plate meter readings were taken in the pre- and post- grazed areas for each group of cows. The regression equations for pre- and post-grazing pasture masses were based on over 140 and 110 calibration cuts, respectively.

Samples representative of pasture offered to cows and of the residual pasture remaining after grazing were collected daily. They were analysed for *in vitro* DM digestibility (IVDMD) by the methods listed by Wales *et al.* (2001) and the IVDMD (%) of pasture consumed by cows was calculated as described by Wales *et al.* (1998). Estimated metabolisable energy (ME) concentration (MJ/kg DM) of the consumed pasture was calculated as: ME = 0.17 x IVDMD - 2.0 (SCA 1990).

All cows were dosed (intrarumenally - fistulated cows; orally - non-fistulated cows) with a slow release alkane capsule (Captec NZ Ltd.) containing the C_{32} and C_{36} even chained alkanes on day 26 of the experiment. Faecal samples were collected, twice daily after milking, between days 33 and 40. Individual faecal samples were frozen and then dried at 60^{o}C, ground through a 1 mm screen and bulked on a dry weight basis for each cow before extraction and analysis for alkanes. To determine concentration of alkanes in the diet, samples of herbage to represent that eaten by the cows were taken daily by cutting to the height of post-grazed pasture in each grazing area. They were freeze dried, ground through a 1 mm screen and bulked on a dry weight basis for each grazing group before analysis for alkanes. The concentration of C_{35} alkane in these samples was less than 10 mg/kg and, hence, the combination of C_{35}/C_{36} alkanes was not used to estimate intake. To enable calculation of the daily dose of C_{32} alkane, capsules were weighed prior to dosing and after recovery from the rumen of fistulated cows on days 33, 36, 38 and 40. The release rates varied from 400 to 470 mg/day with no significant effect of herbage allowance. The average measured release rate (440 mg/day) was used for all non-fistulated cows and this rate was higher than that specified by the manufacturer (400 mg/day).

Alkanes in faeces and herbage were extracted using a modification of the direct saponification method of Dove (1992); omitted was the evaporation of the extract to dryness and redissolution in heptane prior to elution on a silica gel column. Alkane concentrations were measured in a Perkin Elmer Gas Chromatograph fitted with a flame ionisation detector.

Pasture intake was calculated from herbage and faecal concentrations of the natural C_{31} and C_{33} and the dosed C_{32} alkane using the following equation:

$$\text{Daily herbage intake (kg DM/day)} = (F_i/F_j{*}D_j)/(H_i-((F_i/F_j){*}H_j))$$

where F_i and H_i were the faecal and herbage concentrations of C_{31} or C_{33} alkane (mg/kg), F_j and H_j were the faecal and herbage concentrations of C_{32} alkane (mg/kg) and D_j was the daily dose of C_{32} alkane (mg/day).

For PERM, the intake of individual cows was also estimated from the liveweight (W), milk production and condition score change of the cows (Table 1) using energy requirements from SCA (1990). The daily ME requirements for maintenance (ME_m) were estimated as:

$$ME_m = ((1.4(0.28W^{0.75}\exp(-0.03A)))/k_m) + 0.1ME_p + (\text{grazing energy}/k_m) + (\text{energy walking to dairy}/k_m)$$

Liveweight was the average value for a cow from measurements taken after the morning milking on days 33 to 40. The amount of ME used directly for production (MEp) was calculated from net energy required for milk production (NE_l) as follows:

$$NE_l\ (\text{MJ/kg}) = 0.0381\ F + 0.0245\ P + 0.0165\ L$$

where F, P and L were the concentrations (g/kg) of fat, protein and lactose in milk.

Table 1. **Average liveweights, daily milk production and composition during days 33 to 39, condition score change over the whole experiment and daily grazing times for cows grazing perennial ryegrass-based pastures at low or high herbage allowances.**

	Liveweight (kg)	Milk (kg)	Fat (g/kg)	Protein (g/kg)	CS change* (units)	Grazing time (h)
Low allowance	537	20.4	38	28	-0.2	6.6
High allowance	545	24.3	36	30	0	7.9

* 1 to 8 scale

Tissue mobilisation or deposition was estimated by using condition score to determine total body fat percentage of cows at the start and end of the experiment by the equation:

$$\text{Estimated Body Fat \%} = 4.4488 - (1.1603 \times CS) + 0.31028 \times CS^2$$ (Gregory *et al.* 1998).

It was assumed that tissue mobilisation or deposition was uniform over the 41 days of the experiment. Change in body fat percentage was converted to kg of fat using W. The net energy for fat was 39.3 MJ/kg and it was assumed that only fat was mobilised or deposited, as cows were more than 8 weeks into lactation. The efficiency with which fat was mobilised and used for milk production was 0.84 and the efficiency with which dietary ME was used for fat deposition was 0.60.

Additional energy used for grazing was calculated from time spent grazing as 2.5 kJ/h.kg W (SCA 1990) as grazing animals spend longer eating the same amount of DM compared with housed animals. The energy required for cows to walk to and from the dairy twice daily on flat terrain was calculated from distance walked to and from the dairy multiplied by 2.6 kJ/km.kg LW. No account was taken of the energy used for walking while in the grazed strip.

The estimated ME of pasture consumed was assumed to be the same as that determined from samples of pre and post-grazed pasture as described by Wales *et al.* (1998). Pasture intake was calculated by dividing the daily ME requirements of the cow from dietary sources by this estimated ME.

The effects of herbage allowance and method of estimation (PMM, PERM and C_{31}/C_{32} alkanes or PMM, PERM and C_{33}/C_{32} alkanes) on pasture intake were compared by analysis of variance.

RESULTS

Pasture intake increased ($p<0.05$) with herbage allowance for PMM, PERM and when estimated using C_{31}/C_{32} alkanes (Table 2). There was no effect of allowance when C_{33}/C_{32} alkanes were used. Both alkane pairs estimated intakes higher ($p<0.05$) than the other methods and there was an interaction ($p<0.05$) between allowance and method of intake estimation when C_{33}/C_{32} alkanes were used.

Table 2. Pasture intakes (kg DM/cow/day) for cows grazing perennial ryegrass-based pastures at low and high herbage allowance estimated from pre- and post-grazing pasture mass (PMM), production data and published estimates of energy requirements (PERM) or C_{31}/C_{32} and C_{33}/C_{32} alkanes

	PMM	PERM	C_{31}/C_{32} alkanes	C_{33}/C_{32} alkanes
20 kg DM/cow/day allowance	11.8	13.0	17.6	18.5
40 kg DM/cow/day allowance	16.4	15.4	19.6	18.6

s.e.d. for PMM, PERM and C_{31}/C_{32} alkanes comparison for herbage allowance 0.46 and for method 0.75.
s.e.d. for PMM, PERM and C_{33}/C_{32} alkanes comparison for herbage allowance 0.20 and for method 0.43.

Individual cow intake estimates by C_{31}/C_{32} and C_{33}/C_{32} alkanes, respectively, varied 13.8 - 21.5 and 14.3 - 21.7 kg DM/day at the low and 15.8 - 25.2 and 16.2 - 21.3 kg DM/day at the high allowance. The variation between individual cows using PERM was much lower at the low allowance (11.8 - 14.7 kg DM/day) and lower (12.8 - 17.7 kg DM/day) than C_{31}/C_{32} estimates at the high allowance.

DISCUSSION

Pasture intake generally increased with increasing herbage allowance, which is consistent with previous research (Wales *et al.* 1998). However, PMM and PERM appeared to give better estimates of intake and indicated greater effects of herbage allowance. The errors or assumptions that may affect each estimate of intake are discussed below.

Known inaccuracies in PMM are that post-grazing plate meter readings exclude areas that have been defaecated on and, therefore, result in an estimate of residual pasture mass that would be lower than the actual value. The method also assumes no loss of pasture due to trampling. With the number of plate meter readings and calibration cuts taken our errors due to trampling were likely to be small, although their magnitude is unknown. Both errors would result in an overestimation of pasture intake, but the intake estimates by this method were the lowest in this study. Robaina *et al.* (1998) drew attention to the inadequacies of their measurements of post-grazing pasture mass, yet for some treatments estimates of intake by PMM and *n*-alkanes were not different. The comparisons of different methods of intake made by Reeves *et al.* (1996) involved kikuyu pastures where the stoloniferous mat made it difficult to calibrate plate meter readings to herbage mass.

While PMM has given reasonable estimates of the amount of DM removed from the irrigated perennial ryegrass pasture that was being grazed, other errors may affect the estimates of DM intake. Precautions were taken to minimise grazing outside the strip allocated to each group and during movement to and from the dairy. Mayne *et al.* (1997) reported maximum intake rates by fasted cows in short-term grazing of high quality perennial ryegrass of 3.5-4.0 kg DM/hr. If cows on the low herbage allowance were able to graze for up to 20 minutes while travelling to and from the dairy then they may have consumed about 1.2 kg DM outside of the grazed area. Such errors would reconcile the small, but non-significant differences between PMM and PERM at the low herbage allowance.

PERM uses generalised equations to estimate intake and these do not necessarily account for differences between animals in digestion or efficiency of use of nutrients. Hence, while the estimates of intake at a herd level may be reasonable, variation between animals may be underestimated. The following may contribute to errors in PERM estimates of intake. Firstly, the ME concentration of pasture used did not necessarily represent what the cows consumed or derived from the pasture. It was derived from *in vitro* estimates of digestibility calibrated to standards for which *in vivo* digestibility was measured in sheep fed at maintenance. Secondly, while the measurements of live weight, milk production and composition were robust, the estimates of tissue mobilisation or deposition were subject to errors but their contribution was small (<2 MJ ME/day). The calculations used by Reeves *et al.* (1996) did not account for energy used in grazing or walking to and from the dairy and Robaina *et al.* (1998) did not account for the latter. This may account for 1 to 1.5 kg DM/day

Reeves *et al.* (1996) reported increases in estimates of pasture intake as the chain length of the alkane used increased from C_{31}/C_{32} to C_{33}/C_{32} and C_{35}/C_{36} alkanes. The C_{33}/C_{32} alkane pair gave intake estimates that were closest to the PMM and PERM. They concluded that intakes estimated by PMM were not as accurate as those estimated by n-alkanes when cows grazed kikuyu pastures. In the current study, intake estimates by *n*-alkanes indicated pasture utilisation was between 88 and 93% of the pre-grazing pasture mass at the low herbage allowance. The post-grazing pasture mass data (1.9 t DM/ha) indicate these estimates of intake were high. Pasture utilisation at this level is only likely on pure clover swards grazed at restricted allowances (Stockdale 1992). Further, there was a difference in milk production between the low and high herbage allowance treatments of 4 litres, yet the C_{33}/C_{32} alkane pair indicated no difference in ME intake.

Table 3. Sensitivity of the *n*-alkane technique to various assumptions.

Variable	Alteration	Effect on intake estimate
Faecal recovery	C_{33} 5% less than C_{32} or C_{33} 5% more than C_{32}	Increased by 8% or decreased by 8%
Composition of pasture consumed	10% more ryegrass and 10% less clover which increased herbage C_{31} and C_{33} by 7 and 13%	C_{31}/C_{32} estimate decreased by 6% C_{33}/C_{32} estimate decreased by 15%
C_{32} Dose rate	Decreased by 10%	Decreased by 10%

Estimates of intake using alkanes were sensitive to the assumption that faecal recoveries of the alkane pair used were similar (Table 3). Dove and Mayes (1991) reported similar faecal recoveries for C_{33}/C_{32}, but Reeves (1997) reported considerable variation between cows, indicating the magnitude of errors shown in Table 3 were not unreasonable where small numbers of cows have been used.

Inaccuracies in predicting what cows select and differences between individual cows also result in errors with the alkane technique (Newman *et al.* 1998). The pasture grazed in this experiment comprised 51% perennial ryegrass (C_{31}, 212 mg/kg and C_{33}, 92 mg/kg) and 22% white clover (C_{31}, 73 mg/kg and C_{33}, 8 mg/kg). A 10% change in the amount of ryegrass or clover in the material consumed would have markedly affected intake estimates based on C_{31} or C_{33} alkanes (see Table 3). Errors in the dose rate (eg. 400 vs 440 mg/day) would have changed estimates of intake by about 2 kg DM/day (Table 3). Finally, errors in our analyses of alkanes cannot be discounted and may also have led to errors in intake estimates (Newman *et al.* 1998).

It appeared that under the conditions used in this study that PMM and PERM gave better estimates of pasture intake than n-alkanes. However, the alkane technique gave an insight into the considerable variation in intake that may occur within a herd.

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