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COMPARISON OF TECHNIQUES TO ASSESS THE CONCENTRATION OF NUTRIENTS CONSUMED BY DAIRY COWS GRAZING PASTURE IN VICTORIA

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SUMMARY
Two experiments were undertaken to compare the use of pre- and post-grazing sampling of herbage and a cage technique for estimating the concentrations of nutrients consumed by dairy cows grazing pasture in Victoria. The two techniques were compared through spring, summer and autumn in an on-farm monitoring project (experiment 1) and in a controlled experiment where grazing intensity was varied in spring (experiment 2). In experiment 1, there were no significant ($P>0.05$) differences between techniques in relation to the nutritive characteristics of the herbage consumed, with the exception of herbage calcium. The calcium concentrations of the cage herbage samples were significantly ($P<0.05$) higher than those calculated from pre- and post-grazing measurements. In experiment 2, when grazing was hard, both methods of estimating the *in vitro* DM digestibility of the pasture consumed produced similar ($P>0.05$) estimates. When grazing was lax, the estimated digestibility using the pre/post method was 13 digestibility units higher ($P<0.05$) than that estimated using the simulated grazing cuts from herbage protected from grazing by cages. In contrast, there were no differences ($P>0.05$) in crude protein content of the pasture eaten. In conclusion, the cage technique will generally give the most acceptable results, but the sampling of pre- and post-grazed herbage seems to be suitable in all situations except under lax grazing conditions where the removal of small amounts of herbage necessitates more extensive sampling than was undertaken here.

Keywords: nutritive characteristics, herbage consumption, dairy cattle

INTRODUCTION
It is important to know the concentrations of nutrients in herbage grazed by dairy cows so that the many expensive supplements used on dairy farms in southern Australia can be used efficiently. There are several methods available for estimating the nutrient concentration of pasture consumed by grazing animals. The pre- and post-grazing method is the most common method used in dairy research in southern Australia where lactating cows are offered fresh strips of pasture once or twice a day (Kellaway *et al*. 1993; Dalley *et al*. 1999; Stockdale *et al*. 2001). Alternative techniques include plucking samples to grazing height from the sward prior to grazing (Langlands 1974).

The alternative techniques have come under consideration since, on occasions, the pre/post sampling technique can result in unrealistic data. A variation on the plucking technique is to use cages to prevent stock from interfering with small areas of pasture while grazing the rest of the paddock, then plucking (cutting) the untouched material to a level consistent with the grazed pasture adjacent to it. Laboratory analyses can then be conducted on the plucked material with the assumption being that this is the herbage actually ingested by the cows. These two techniques were compared in two experiments, one in an on-farm monitoring project in northern Victoria and the other in a controlled experiment in southern Victoria where grazing intensity was varied.

MATERIALS AND METHODS
Experiment 1
The pastures on four dairy farms were intensively sampled over a 9-month period (Stockdale *et al*. 2001). Each farm was visited for a week each month, from September 1996 to May 1997. On 4 days of each week, a quadrat (0.245 m^2) was cut to ground level in the paddock the cows were to graze next. Within each quadrat, rising plate meter height (Earle and McGowan 1979), mass and nutritive characteristics (organic matter, *in vitro* DM digestibility (DMD), nitrogen (N), neutral detergent fibre (NDF), acid detergent fibre (ADF), and macro-minerals) of the pasture were measured. At the time that each quadrat was cut, a 'paired' quadrat was marked with pegs so that, after the paddock had been grazed, measurements similar to those made for the ungrazed pasture could be repeated for the

residual herbage. When the paired quadrats were selected each day, a third similar quadrat was enclosed by a cage to exclude stock, being subsequently cut to the height to which the post-grazing quadrat had been grazed.

After measuring the rising plate meter height of each quadrat, all plant material was removed by cutting to ground level with hand shears. Herbage mass was determined by drying the sample at 60^{o}C for 3 to 7 days in a forced draught oven. Each sample was then ground through a 1 mm screen, and analysed for its nutritive characteristics.

Samples were analysed for organic matter, by ashing in a muffle furnace at 520^{o}C for 3 hours, DMD by pepsin-cellulase digestion (Clarke *et al*. 1982), and total N using a Leco FP-428 (Leco Australia Pty Ltd). Crude protein content was calculated using N% x 6.25. Neutral detergent fibre and ADF were determined using a modification of the methods described by Van Soest *et al*. (1991), whereby the amylase steps were omitted because the samples filtered freely. Samples were also analysed for phosphorus, potassium, calcium, magnesium, sodium, sulphur and chlorine with an automated X-ray fluorescence spectrometer (PW 1404, Philips Scientific and Industrial Equipment), using a method based on the work of Hutton and Norrish (1977) and Norrish and Hutton (1977). Any data with organic matter values greater than 13% were discarded since this level was used as an indicator of soil and/or faecal contamination.

Nutrient concentrations in the pasture eaten were calculated from differences between the pre- and post-grazing characteristics using an equation described by Wales *et al*. (1998):

$$Nutrient_{eaten}\ (\%\ DM) = [(Herbage\ Mass_{pre} \times Nutrient\ Concentration_{pre}) - (Herbage\ Mass_{post} \times Nutrient\ Concentration_{post})]/(Mass_{pre} - Mass_{post}).$$

With the cage technique, the nutrient concentrations in the pasture consumed were obtained directly from the chemical analyses.

The data on nutritive characteristics of the herbage consumed were analysed by two-way analysis of variance with no blocking (Genstat V). Technique and season of the year were the 2 variables in this analysis. In almost all cases, there was a significant ($P<0.01$) effect of season, but the interaction between season and technique was not significant ($P>0.05$) in any instance. Therefore, only results for the technique comparison are presented.

Experiment 2

Experiment 2 was conducted in southern Victoria during August 1995. The experimental design was a 2 x 2 factorial, with two intensities of grazing (lax and hard) and two methods of estimating the concentrations of nutrients consumed by cows. The experimental area was comprised of a 1-hectare paddock of perennial ryegrass (*Lolium perenne*)/white clover (*Trifolium repens*) pasture, divided in two from north to south. On one occasion, the west side of the paddock was grazed with lactating dairy cattle for 12 hours while the east side was grazed with the same cows for a 24-hour period.

Prior to the cows entering the treatment areas, 20 protection cages (0.25 m^2) were randomly placed throughout each of the two areas to protect the pasture beneath from being grazed. At the same time, an electric shearing handpiece was used to cut the pasture within a 0.2 m^2 quadrat adjacent to each cage to ground level. These samples were washed in cold water and dried at 65^{o}C for 48 hours. Following grazing, a second quadrat adjacent to each cage was harvested and treated as per the pre-grazing quadrat. The cages were then removed and the pasture beneath cut to heights representative of the surrounding area. These samples were also washed in cold water prior to drying at 65^{o}C for 48 hours.

All herbage samples were analysed for DMD (Clarke *et al*. 1982) and Kjeldahl N. Similar calculations were performed as in experiment 1 and the data were analysed as a 2*2 factorial analysis of variance using Genstat V.

RESULTS

Experiment 1

There was a good relationship between post-grazing rising plate meter heights with the two techniques (Figure 1). The average amounts of herbage removed (±s.d.) were 1032 (±451.6) and 1030 (±640.9)

kg DM/ha for the cage and the difference techniques, respectively. Table 1 provides the results of the comparison between the two techniques. There were no significant differences between techniques in relation to the nutritive characteristics of the herbage consumed, with the exception of herbage calcium. The calcium concentrations of the cage samples were significantly higher than those calculated from pre- and post-grazing measurements.

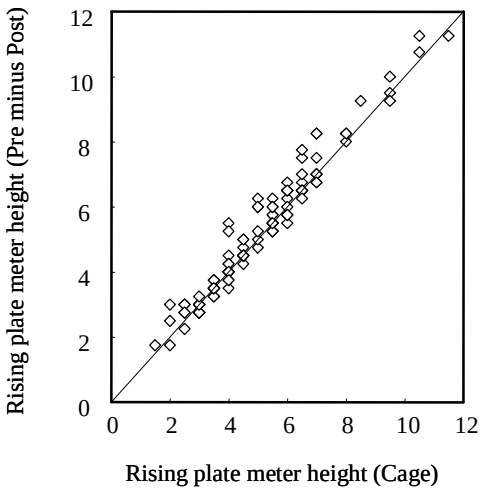

Figure 1. The relationship between post-grazing rising plate meter heights for the cage and the pre/post techniques in experiment 1

Table 1. Comparisons of the nutritive characteristics of herbage consumed (% DM) obtained either from plucking material that remained under a cage after the sward had been grazed or from calculations involving pre- and post-grazed herbage in experiment 1

Nutritive characteristic	Technique		
	Cage	Pre – Post	s.e.d.
In vitro DM digestibility	74.3	74.2	0.96
Crude protein	20.2	20.1	0.76
Neutral detergent fibre	47.3	46.2	1.82
Acid detergent fibre	25.8	26.6	0.87
Phosphorus	0.32	0.33	0.014
Potassium	2.09	1.97	0.136
Calcium	0.49^{A}	0.61^{B}	0.038
Magnesium	0.31	0.33	0.014
Sodium	0.58	0.57	0.070
Sulphur	0.28	0.26	0.017
Chlorine	1.39	1.32	0.113

$^{A, B}$ Values in rows followed by different superscripts are significantly different (P<0.05)

Experiment 2

Due to the uneven nature of the paddock being grazed, there were differences in the pre-grazing heights and masses of the two areas (Table 2). Despite these differences, the lax grazing removed approximately 690 kg DM/ha compared with 900 kg DM/ha during the hard grazing. When grazing was hard, both methods of estimating the DMD of the pasture consumed produced similar estimates. However, when grazing was lax, the estimated DMD using the pre/post method was 13 digestibility units higher than that estimated using simulated grazing by cutting to grazing height (Table 3). In contrast, there were no differences (P>0.05) between techniques in crude protein concentration of herbage consumed.

Table 2. Height (according to the rising plate meter) and mass of the pasture before and after grazing in experiment 2

	Grazing intensity		
	Lax	Hard	s.e.d.
Pre-grazing height (cm)	8.4^{A}	5.3^{B}	0.68
Post-grazing height (cm)	4.3^{A}	2.2^{B}	0.32
Pre-grazing mass (kg DM/ha)	2540^{A}	1850^{B}	158
Post-grazing mass (kg DM/ha)	1850^{A}	950^{B}	97

$^{A, B}$ Values in rows followed by different superscripts are significantly different (P<0.05)

Table 3. Comparisons of the nutritive characteristics of herbage consumed (% DM) obtained either from plucking material that remained under a cage after the sward had been grazed or from calculations involving pre- and post-grazed herbage at each grazing intensity in experiment 2

Nutritive characteristics	Lax grazing		Hard grazing		s.e.d.
	Cage	Pre – Post	Cage	Pre – Post	
In vitro DM digestibility	82.4[A]	94.6[B]	82.6	85.3	4.12
Crude protein	20.2	21.3	20.0	19.1	1.92

[A, B] Values in rows, at a particular grazing intensity, followed by different superscripts are significantly different (P<0.05)

DISCUSSION

In experiment 1, the technique of sampling pasture before and after grazing to assess the pasture nutrients consumed by cows was comparable with the cage technique, providing ash contents were measured so that the results of samples with unacceptably high organic matter loads could be discarded. However, it is unclear why the results for calcium were the exception.

The results of experiment 2 clearly showed that lax grazing, where grazing is likely to be more variable than with harder grazing, results in unacceptable results when the pre/post technique is used. One reason for this is likely to be the large amount of sampling that would need to be undertaken to account for the high levels of variability generally seen in laxly grazed pasture. Wales *et al*. (1998) studied the herbage consumption of cows with daily pasture allowances ranging from 15 to 75 kg DM/cow and obtained realistic values at all allowances. However, their sampling regimes included daily sampling that increased as herbage allowance increased. Although Popp *et al*. (1999) considered soil contamination to be a disadvantage with the herbage sampling techniques, washing and ashing allowed us to avoid this problem thereby removing it as a confounding factor in the assessment of techniques.

While the plucking technique appears logical and easy, the ability to be able to pluck (cut) to the height to which cows have grazed is often difficult, particularly with short pasture. However, the generation of unrealistic results will be less of an issue with the cage technique than with the pre/post technique. In conclusion, the cage technique will generally give the most acceptable results, although the sampling of pre- and post-grazed herbage seems to be suitable in all situations except under lax grazing conditions, where the removal of small amounts of herbage will necessitate more extensive sampling than was undertaken here.

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