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Growing grass and clover separately allows animals to sustain a high nutrient intake

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ABSTRACT

White clover has high nutritive value but the proportion in mixed pasture and therefore the diet, is often low. Offering sheep ryegrass and clover growing side-by-side, for short periods, increases the proportion of clover in the diet and daily intake compared to a mixed pasture. This experiment tested whether sheep offered ryegrass and clover side-by-side could sustain a high proportion of clover in their diet and a high daily intake, compared with sheep grazing ryegrass alone, clover alone and ryegrass and white clover growing as a mixed sward. Forty-eight dry, non-pregnant Romney ewes (56 ± 1.8kg live weight) were randomly allocated to four replicates (two spatial x two temporal) of each treatment (n=3) for 12 days. Average grazing time was 292 ± 16.2 min/day and did not differ significantly among treatments. Short-term intake rate on clover (5.0 g/min) was higher than ryegrass (3.5 g/min) (P=0.02). As a result, clover dominant diets supported higher daily intake (1.36 kg/d for clover alone vs. 1.08 kg/d for ryegrass alone). Sheep sustained a diet of 70% clover and 30% ryegrass, showing that predominance of clover in the diet was not a result of novelty. This improved daily intake would provide significant benefit to animal production systems and can be achieved simply by growing grass and clover separately.

Keywords: grazing behaviour; intake; ryegrass; clover; meals; nutrient intake.

INTRODUCTION

Pasture-based production systems in New Zealand typically comprise mixtures of white clover with a range of temperate grasses, predominantly perennial ryegrass. White clover has a high nutritive value compared with ryegrass (Ulyatt *et. al.,* 1988*)* and, when given equal opportunity, animals prefer it (Parsons *et al.,* 1994). However, mixed pastures often contain a low proportion (5-15%) of white clover (Clark & Ulyatt, 1985), which results in low proportions in animal diets. Inter-specific competition is one factor that suppresses the proportion of clover, but sustained selection pressure from animals further reduces its proportion (Parsons *et al.,* 1991). Despite many years of research, it is difficult in practice to maintain mixed swards, and therefore diets, with a high proportion of clover.

Growing grass and clover separately, side-by-side, and giving sheep free access to both, allows them to substantially increase the proportion of clover in their diet compared to an intermingled mixed sward. This increase results from the high proportion of time they spend grazing clover, and the higher intake rate while grazing clover, compared with ryegrass (Penning *et al.,* 1991). Work by Champion *et al.* (1998) with ewes in the eighth week of lactation, and by Cosgrove *et al.* (1999) with dry ewes over two days, showed that offering grass and clover growing separately can also stimulate sheep to combine a long daily grazing time with their preference for a high proportion of clover in the diet. This combination can further boost nutrient intake compared with sheep offered grass alone or clover alone. This experiment tested whether sheep offered a side-by-side choice could sustain both the high proportion of clover in their diet and the high daily intake over a longer period.

MATERIALS AND METHODS

Sward Preparation and Management: Eight plots of 0.2ha were sown with either perennial ryegrass alone (*Lolium perenne* L.) cv. Yatsyn, white clover alone (*Trifolium repens* L.) cv. Pitau, or an intermingled mixture of the two with 16% clover in the sward by mass. This provided four treatments; perennial ryegrass alone, white clover alone, a choice between monocultures of ryegrass and white clover growing side-by-side (choice treatment with 0.1ha of each species) and a ryegrass/white clover mixture. The trial was run in May 2000 at the AgResearch, Aorangi research station in the Manawatu. Sward surface height of all plots was maintained at 9cm (measured using a sward stick) throughout the trial by mowing. This height was maintained to ensure feed was available *ad libitum*, and plots were large enough to ensure depletion did not affect feed availability, grazing behaviour or preference. Hand-plucked forage samples were taken during each run to simulate grazing. They were freeze dried, ground and sub-samples were analysed by near infrared reflectance spectroscopy.

Experimental Design and Measurements

This experiment was conducted in two parts: measuring firstly, the grazing behaviour of sheep exposed to treatments for 12 days, and secondly, their short-term intake rate of dry matter (IR) from each treatment. The product of time spent grazing and IR is an estimate of daily dry matter intake. This method was also used to calculate the intake of grass and clover selected by sheep offered the choice, and the proportion of each in their diet.

Grazing Behaviour: There were two spatial replications of the four pasture treatments. Forty-eight dry Romney ewes (56 ± 1.8kg live weight) were divided into two groups of 24. Twenty-four sheep were randomly divided into eight groups of three and allocated to the

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two replicates of each treatment for 12 days. At the completion of this period, the other twenty-four were allocated in groups of three to the same plots also for 12 days. This combination of two spatial replicates and two repeats of the 12 day experimental period was used as four replications in the statistical analysis. All sheep grazed on a ryegrass/white clover mixed sward for two days before the start of each run. The time spent grazing by individual sheep was determined from 12hrs of visual observations during daylight on four days (day 1, 4, 7, 12) during each 12-day run, and recording at 1-minute intervals whether they were grazing or not. Grazing at night is limited (Penning *et al.*, 1991) and was assumed to be negligible for the purpose of estimating daily intake. Meals were identified as bouts of grazing of six minutes or longer. For the choice treatment, meals of three types (ryegrass only, clover only, and a mixed meal composed of both species) were taken, but further consideration was based only on mixed meals because of their predominance in number and duration.

Short-Term Intake Rate: Short-term intake rate (IR) of dry matter was determined by measuring weight changes of sheep during grazing in the afternoon (Penning & Hooper, 1985). A subset of 12 of the sheep used above were randomly allocated into four groups, and groups were allocated to treatments using a Latin-square design. Sheep were fitted with urine/feceas collection bags and weighed, then stood for 1hr and weighed again to determine insensible weight loss. Sheep were then allowed to graze for approximately 1hr (until one meal was taken) and re-weighed to get weight gain due to feed intake. Sheep were exposed to each treatment for 24hr before IR was measured. Intake rate by sheep offered the choice treatment was measured only for the clover part, for the following reason. On the basis of previous work clover was expected to form the larger part of the diet (Newman *et al.*, 1992; Parsons *et al.*, 1994). Due to its higher proportion in the diet a difference in IR between sheep grazing clover alone, and sheep grazing the clover part of the choice would introduce an arithmetically greater error in calculated daily intake than a difference of similar magnitude in IR between sheep grazing ryegrass alone and sheep grazing the ryegrass part of the choice. Intake rate while grazing the ryegrass part of the choice was assumed to be the same as for ryegrass alone in the calculation of intake from ryegrass and total daily intake.

Data Analysis: The experimental unit was the group of three animals exposed to a given treatment for both behaviour and intake rate measurements. Treatment means were statistically compared using ANOVA. Each data set contained 16 observations, and treatment effect (3 d.f.) was tested against replicate by treatment interaction (9 d.f.). This was a pooled error term comprised of the interaction between replicates within both runs (2 d.f.) and runs (1 d.f.) x treatment (3 d.f.).

RESULTS AND DISCUSSION

Grazing time and intake rate

Short-term intake rate on clover (5.0 gDM/min) or the clover part of the choice treatment (5.6 gDM/min) were significantly greater than on grass (3.5 gDM/min; Table 1). The time spent grazing on grass alone (310 min/day) was greater than on clover alone (280 min/day).

These differences between grass and clover for both IR and time spent grazing are consistent with the results of Penning *et al.* (1991). In the present study, IR on the mixture was intermediate between the IR on grass alone and clover alone, and grazing time was not significantly different when compared across all four treatments (Table 1). The time spent grazing on the choice (280 min/d) was comprised of 170 min/day grazing clover and 110 min/day grazing grass. This indicates a preference for clover, sheep spending 62% of total daily grazing time on clover, and, when scaled by relative IR, the proportion of clover in the diet was 70%.

Benefits of a side-by-side choice

The high proportion of clover in the diet was sustained over the 12-day period and was not due to novelty. During the period of this experiment there were day-to-day fluctuations in the proportion of clover in the diet, but there was no significant difference among days (data not shown) in the time spent grazing each species. Day-to-day fluctuations in behaviour have been observed in other work (Pfister *et al.*, 1997; Forbes and Provenza, 2000) and appear to be a normal part of grazing behaviour. Penning *et al.* (1991) showed that daily intake of DM on clover alone is not always greater than on grass alone because the higher IR on clover is offset by shorter grazing time. An estimate of total daily intake (calculated from grazing time and intake rate, Table 1) shows that, in the present study, sheep grazing clover alone, or grass and clover growing side-by-side, did achieve higher daily DM intake than sheep grazing ryegrass alone. Ryegrass had significantly lower protein and soluble carbohydrate concentrations (270 vs. 300 g/kg, P = 0.0004; 110 vs.

TABLE 1: Short-term intake rate, grazing time and calculated daily intake of sheep offered ryegrass alone, clover alone, a mixture of ryegrass and clover, and ryegrass and clover growing side-by-side.

	Treatments						P [1]
	Clover alone	Ryegrass alone	Mixture	Choice			
Measurement				Total	Ryegrass	Clover	
Intake Rate (g DM/min)	5.0	3.5	4.3	-	3.5 [2]	5.6	0.025
Grazing Time (min/day)	270	310	310	280	110	170	0.271
Estimated Daily Intake (g/day)	1360	1080	1330	1340	370	970	- [3]

[1] P values indicate difference between the three main treatments not the breakdown of the choice treatment

[2] Intake rate for the ryegrass part of the choice was not measured so this value has been assumed to be the same as for ryegrass alone in calculation of daily intake

[3] Daily intake values are derived from the product of IR and GT and no separate statistical analysis was possible

TABLE 2: The number of meals per day and the mean duration of meals for sheep offered clover alone, ryegrass alone and a choice of ryegrass and clover growing side-by-side. Data from related experiments with sheep and cows is included for comparison (see footnotes for details)

Measurement	Data Set[1]	Treatments						P [2]
		Clover	Ryegrass	All Meal Types	Choice Mixed Meals Only			
					Total	Clover	Ryegrass	
Number of meals per day	Trial Sheep 1	6.1	5.6	6.8	3.7	-	-	0.07
	Trial Sheep 2	8.4	7.2	9.8	5.8	-	-	0.03
	Lactating Cows	6.7	4.6	6.3	3.4	-	-	0.04
Meal duration (min)	Trial Sheep 1	45	57	43	52	29	23	0.01
	Trial Sheep 2	38	62	49	62	30	31	0.01
	Lactating Cows	60	111	73	102	69	27	0.01

[1]Trial Sheep 1 = primary data set presented in this paper;
Trial Sheep 2 = comparison data set; see Cosgrove *et al.* (1999) for experimental details;
Lactating cows = comparison data set; see Marotti *et al.* (2001) for experimental details
[2] P values indicate the significance of difference amoung the three main treatments not the breakdown of the choice treatment

135 g/kg, P = 0.01 for ryegrass and clover respectively) and higher NDF (400 vs. 290 g/kg, P = 0.0001). The high proportion of clover in the diet and the high nutrient density of clover indicate the differences in nutrient intake would be even greater than in dry matter intake.

Behaviour at the level of meals

Animals grazing grass alone or clover alone clearly use different combinations of IR and grazing time to achieve similar total daily intakes. Food intake is not a continuous process, but is made up from discrete meals (Penning *et al.*, 1991). The number and duration of meals is valuable to understand what opportunities may arise by presenting forage in different ways.

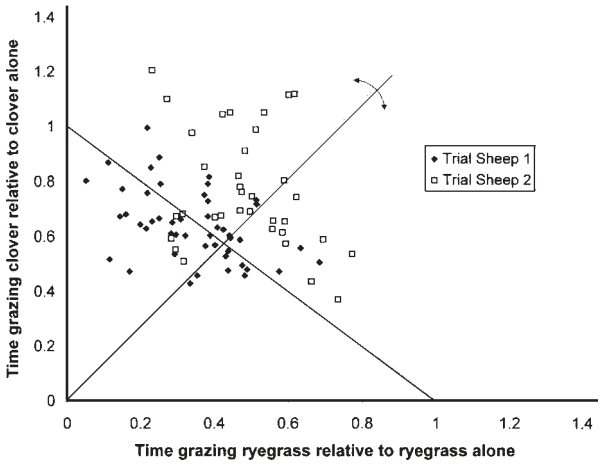
When animals are offered a choice of species to graze, daily intake can consist of meals of 3 different types (clover only, ryegrass only, and mixed meals of both species). Sheep grazing clover typically take more frequent meals but of shorter duration than sheep grazing ryegrass (Penning *et al.*, 1991). This is confirmed here (Table 2).

The majority of meals (by number) are mixed meals, and their greater duration compared with the mean of all meal types indicates they have a longer duration than meals of grass only or clover only. An expected meal length for mixed meals was calculated by weighting the average meal length for animals offered clover alone or ryegrass alone by the preference shown for each species when animals were offered a choice. For example, using results from this experiment, in which sheep took meals of 45 min on clover alone and 57 min on ryegrass alone, the expected duration of a mixed meal was 49 mins [(45 x 0.7) + (57 x 0.3)]. The average duration of mixed meals taken on the choice was 52 min (Table 2). This was longer than meal length when offered clover alone (45 min) and was not significantly different from the calculated expectation of 49 min ($t_{0.05}$-statistic 6.7; 48 observations). For comparison, data on meals from an earlier experiment (Cosgrove *et al.*, 1999) are included in Table 2. In that work, sheep offered the choice treatment had an average meal length significantly longer than the expectation (62 vs. 47 min; $t_{0.01}$-statistic 10.1; 18 observations), and as long as on ryegrass alone (Table 2). Offering a choice allows animals flexibility in regulating the number and duration of mixed meals and flexibility in the combination of grazing time and IR that makes up daily intake.

However, is there any evidence of an increase in daily grazing time, which might provide further benefits from a side-by-side choice, for example, by combining the advantages of high IR on clover with the long grazing time on grass? Offering a choice can clearly stimulate an increase in grazing time above that expected from behaviour on each species alone (Figure 1).

There are points above the line for both data sets showing that in some circumstances animals have a higher daily grazing time relative to the expectation. Both data sets were standardized as described below, because total

FIGURE 1. The time spent grazing by sheep on ryegrass and clover as part of a side-by-side choice relative to the grazing time of sheep on each species alone, for two separate data sets. The 1:1 line is shown in bold. The dotted line from the origin indicates that a point sitting anywhere along this line shows 50:50 preference for grass and clover. Increasing the slope of the line would indicate an increased preference for clover. Trial Sheep 1 = primary data set presented in this paper; Trial Sheep 2 = comparison data set from Cosgrove *et al.* (1999)



daily grazing times were different for both experiments. Average daily grazing time when offered ryegrass alone or clover alone was used as the expectation for daily grazing time on each species of the choice, respectively. Daily grazing time on the clover part of the choice was divided by average daily grazing time on clover alone. Daily grazing time on the ryegrass part of the choice was divided by average daily grazing time on ryegrass alone, converting both to relative values, thereby allowing comparison across the two data sets. Points above the 1:1 line indicate an animal that grazed longer than expected, i.e., an increased grazing time. Both data sets showed that sheep may increase their grazing time, however, animals did not always take this opportunity. Data points for this experiment are skewed to the left indicating a preference for clover over ryegrass. In the other data set (Cosgrove *et al.,* 1999) sheep showed no preference for clover, suggesting a possible inverse relationship between the strength of preference for clover and the likelihood of a stimulus to total daily grazing time (Figure 1).

Effects of nutritional demand on meals

With or without any subtle changes in intake behaviour (meal length, grazing time) there are still significant benefits from offering animals a side-by-side choice. Work conducted with lactating dairy cows in Victoria, Australia shows that offering a choice significantly increases milk production even without animals utilising the opportunity to increase grazing time (Marotti *et al.*, 2001). Lactating dairy cows, which have a nutritional demand well above maintenance, were offered the same four treatments as in this experiment and detailed grazing behaviour measurements were made. Duration of mixed meals was significantly longer than expected (102 vs. 73 min; $t_{0.01}$-statistic 22.8; 36 observations) (Table 2), and, in these mixed meals, the time spent grazing the clover part of the choice was longer even than the duration of meals by cows offered clover alone. In each mixed meal, cows added to this time on clover the time spent grazing grass, resulting in greater total duration and intake per meal than expected, and of course, greater nutrient intake (greater intake and more of this is from highly nutritious clover). This resulted in milk production on the ryegrass/clover side-by-side choice being 28% greater than on ryegrass alone and 11% greater than on a newly established mixed sward containing 20% clover (Marotti *et al.*, 2001).

CONCLUSIONS

Sheep can easily achieve and sustain a diet with 70% clover when offered ryegrass and clover growing side-by-side. This is a greater proportion than animals can achieve when offered a typical mixed sward. A high daily nutrient intake can, therefore, result from both the high IR on clover and the high proportion of clover in the diet. In the present study, the time spent grazing each day and proportion of clover in the diet did not change over the experimental period, indicating that the responses observed were not a result of novelty and these benefits can be sustained. This offers a significant potential benefit to pasture-based animal-production systems, as shown by the lactating dairy cows in which milk production increased by 28% compared to cows grazing ryegrass alone, or ryegrass-dominant pastures. Further studies could resolve what circumstances are required to consistently stimulate an increase to total daily grazing time, and what factors (nutritional or otherwise) drive animals to select mixed meals, and the apparently beneficial mixed diets.

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