temperature and length of storage with seed that had passed through the digestive tract (M. Simao Neto, unpublished data). Legume seed which was still hard after passage would be resistant to storage in faeces. Soft legume or grass seed that was excreted in faeces would be susceptable to storage in faeces, possibly even more so than the seed used in this study. It is not surprising that storage at 35 °C or 35 °/10 °C had little effect on hard legume seed because higher temperatures than this are required to break hardseededness of dry seed (Mott *et al.* 1981).

Although there are good descriptions of the longevity of dung patches in pastures (Marsh and Campling 1970; Ferrar 1975), we were unable to find data for faecal temperatures following the deposition of faeces from grazing cattle. Temperatures in faeces would depend on ambient temperature, direct radiation, the moisture content and biological activity of faeces, and the presence of dung beetles. Temperatures of 35 °C, 35 °/10 °C and 10 °C were chosen to provide contrasting regimes within the likely range of summer and winter temperatures of wet faeces in the tropics.

If it is desired to introduce or disseminate a legume species via the grazing animal, then a high initial level of hard seed is most important. Firstly, little soft seed remains viable after passage through the digestive tract of ruminants (Simao Neto *et al.*, 1987). Secondly, as this study shows, soft seed is also likely to be destroyed by retention in cattle faeces. In contrast, viability of seeds within faecal pellets of sheep and goats, as compared with cattle faeces, may well be less affected because the dung pellets are smaller and usually have a lower moisture content.

This experiment has demonstrated that grass seed and soft legume seed of tropical pasture species stored in faeces is markedly reduced in viability within 7 to 21 days. To relate this information more directly to faecal patches excreted by grazing animals we need information on micro-environmental conditions within excreted faecal patches.

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OBSERVATIONS ON THE DIET SELECTED BY FRIESIAN COWS GRAZING TROPICAL GRASS AND GRASS-LEGUME PASTURES

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ABSTRACT

The composition of the diet selected by Friesian cows grazing pure tropical grass pasture containing Panicum maximum *cv. Gatton and mixed tropical pasture containing* P. maximum *cv. Gatton and the legumes* Neonotonia wightii *cv. Tinaroo and* Desmodium intortum *cv. Greenleaf was measured during summer and winter on the*

Atherton Tablelands, north Queensland. The grass pasture was stocked at 2.0 and 3.5 cows ha^{-1}, and received 200 and 400 kg N ha^{-1} $year^{-1}$ at each stocking rate. The grass-legume pasture was stocked at 2.0 cows ha^{-1} and received no nitrogen fertilizer. All pastures were grazed on a rotation of one week grazing, three weeks spelling, and samples of the diet determined with oesophageally fistulated heifers.

With pure grass pastures there was a rapid decline in the leaf content of the diet during the first three days of the week, and an associated increase in stem and dead material. Crude protein content of the diet exceeded 12% in the dry matter only during the first two days of each week. The effects of stocking rate and fertilizer level were evident early and late in the week, but were small in relation to the changes as the pasture was grazed down.

There was less variation in the composition of the diet of cows grazing grass-legume pastures, but the crude protein content of the diet again only exceeded 12% in the first two days of the week. For grass pastures the results show a close association between leaf percentage in the diet and both leaf yield on offer and total pasture yield on offer. Grazing time was reduced when yield of grass leaf was less than 1.0 t DM ha^{-1}. Milk production varied by up to 25% during the week, with peak values being on days 2 and 3 and the minimum value on day 7.

INTRODUCTION

The ability of dairy cows to graze plants or parts of plants selectively is an important determinant of the quality of the diet. Stobbs (1973) showed that cows will consume leaf in preference to stem, and in short, intensive periods of grazing, intake was at a maximum when pastures were short and contained a high percentage of leaf. One object of grazing management is to develop desirable characteristics in a pasture, such as a high leaf percentage, and so maintain diet quality. However there are very few data on the composition of the diet for cows grazing tropical pastures and the present observations were made to define the composition of the diet selected by Friesian cows from pure tropical grass pastures and tropical grass-legume pastures under rotational grazing.

MATERIALS AND METHODS

Location

The observations were made at Kairi Research Station on the Atherton Tablelands, north Queensland (17°14′S, 145°43′E, altitude 700 m). Average annual rainfall is 1285 mm, of which 80% falls from December to April inclusively. There was adequate soil moisture for pasture growth throughout the periods of observation.

Pastures and animals

In 1975–76 an experiment was established to measure milk yield by Friesian cows grazing pure grass pasture (*Panicum maximum* cv. Gatton) and grass-legume pasture (*P. maximum* cv. Gatton, *Neonotonia wightii* cv. Tinaroo and *Desmodium intortum* cv. Greenleaf). For grass pastures there were two levels of nitrogen fertilizer (200 and 400 kg N ha^{-1} $year^{-1}$) and four stocking rates (2.0, 2.5, 3.0 and 3.5 cows ha^{-1}) (Davison *et al.* 1985). The grass-legume pastures were grazed by two groups of cows at 2 cows ha^{-1}. The ten treatments were allocated at random to each of four blocks of pasture, and throughout the experiment these blocks were grazed on a one week grazing, three weeks spelling rotation. Nitrogen fertilizer was applied as ammonium nitrate in November, February, May and September, with 60% of the nitrogen being applied in November and February.

In November 1976, thirty Friesian cows and 10 Friesian heifers were blocked on parity, previous production by cows and liveweight, and allocated at random to treatments. Animals calved from September to December inclusively.

The two grass-legume treatments, and the four grass treatments stocked at 2.0 and

3.5 cows ha^{-1} (200 and 400 N at each stocking rate) were chosen for observations on diet selection. The treatment effects on milk production have been published separately (Davison and Cowan 1978; Davison *et al.* 1985).

Measurements

Observations on selective grazing were made twice during lactation, from February 9 to 24, 1977 (summer) and June 29 to July 21, 1977 (winter). Before and after each week of grazing, pasture on offer was measured by cutting eight 0.4 m^2 quadrats to 3 cm stubble height from each paddock. Pasture from the eight quadrats was bulked, weighed and two subsamples taken for determination of dry matter and grass leaf, grass stem, legume and dead contents. Material was dried for 36 h at 80 °C, weighed, and leaf, stem and legume ground through a 1 mm screen before analysis for nitrogen content (Kjell-Foss) and *in vitro* dry matter digestibility (IVDMD) (Minson and McLeod 1972). Pasture height was recorded for each paddock by taking 25 random measurements of height to the tip of the flag leaf on the pasture after it was cut.

Dietry samples of the selectively grazed pastures were collected using oesophageally fistulated heifers on days 1, 3, 5 and 7 of each sampling week. The four oesophageally fistulated heifers of mean liveweight 400 kg were maintained on mixed pastures of green panic (*P. maximum* cv. trichoglume) and glycine. On the night before sampling they were confined to yards with only water. Pasture samples were collected from 8.00 a.m. to 10.00 a.m. with two animals sampling each paddock for approximately 15 mins. The order in which paddocks were sampled and the animals used to sample individual paddocks were changed at each sampling to avoid the confounding of time or animals with treatment. A foam rubber sponge was inserted into the lower oesophagus to ensure complete collection of the sample in canvas bags with gauze bottoms to allow excess saliva to drain away. Approximately 1 kg of material was collected from each animal. Samples from the two heifers were bulked, squeezed through a double layer of muslin cloth and divided into two. One half was frozen for later determination of grass leaf, grass stem, legume and dead by sorting, drying and weighing (Chacon *et al.* 1977). The second sample was dried at 70 °C for 24 h, ground through a 1 mm screen and analysed for nitrogen and IVDMD as for pasture samples.

Milk yields of cows were measured daily. The time spent grazing was measured using vibracorders (Stobbs 1970). In summer, the vibracorders were attached to one cow from each treatment throughout each week of the rotation. In winter they were attached to two cows from each treatment for days 2, 3 and 4 and to two different cows for days 5, 6 and 7 of each week.

RESULTS

Pasture on offer

There were large differences between treatments in the height of pasture, both before and after grazing (Table 1). There was a close relationship between total pasture on offer and pasture height, which could be described by a single equation for both summer and winter. The equation was—

$$Y = 179 + 67X \quad (r = 0.99;\ P < 0.01;\ SE_b = 8)$$

where Y = total pasture on offer (kg DM ha^{-1}) and X = pasture height (cm).

Grazing reduced the amounts of grass leaf and stem on offer, with a relatively greater reduction in leaf than in stem. Dead material increased during the week. In summer the amounts of grass leaf on offer before grazing were similar among the grass pastures, whereas in winter there were large differences between treatments in the amounts of grass leaf on offer.

The crude protein content of grass leaf was high, while that of the stem was much lower (Table 2). The IVDMD was also higher in leaf than in stem.

TABLE 1

Pasture on offer (t DM ha^{-1}) and height (cm) before and after grazing in summer and winter

Component	Fertilizer nitrogen (kg N ha^{-1} yr^{-1}) 200	200	400	400	0*	
	Stocking rate (cows ha^{-1}) 2.0	3.5	2.0	3.5	2.0	SE
Summer						
Before grazing						
Height	64	49	82	53	57	2
Grass leaf	0.96	0.90	1.07	0.93	0.70	0.09
Grass stem	3.06	2.37	4.15	3.06	2.04	0.34
Dead	0.75	0.58	0.73	0.60	0.39	0.09
Legume	0.25	0.11	0.04	0.22	1.14	0.38
Total weight	5.02	3.96	5.99	4.81	4.27	0.47
After grazing						
Height	46	37	66	40	39	3
Grass leaf	0.60	0.37	0.65	0.35	0.39	0.05
Grass stem	2.80	1.66	3.31	1.81	1.52	0.17
Dead	0.95	0.45	0.89	0.65	0.58	0.07
Legume	0.24	0.05	0.01	0.03	0.73	0.13
Total weight	4.59	2.53	4.86	2.84	3.22	0.13
Winter						
Before grazing						
Height	43	27	51	33	36	2
Grass leaf	1.00	0.64	1.49	0.99	0.40	0.08
Grass stem	2.81	1.10	3.30	1.69	1.14	0.30
Dead	1.25	0.89	1.24	0.81	0.91	0.11
Legume	—	—	—	—	1.08	0.26
Total weight	5.06	2.63	6.03	3.49	3.53	0.45
After grazing						
Height	34	19	40	22	31	2
Grass leaf	0.61	0.21	0.63	0.29	0.27	0.05
Grass stem	2.27	0.67	2.74	1.22	1.06	0.22
Dead	1.49	0.89	1.55	1.03	1.02	0.14
Legume	—	—	—	—	0.87	0.30
Total weight	4.37	1.77	4.92	2.54	3.22	0.27

* Grass-legume pasture

TABLE 2

Crude protein (N × 6.25) and IVDMD of pastures before grazing

Component	Fertilizer nitrogen (kg N ha^{-1} yr^{-1}) 200	200	400	400	0*	
	Stocking rate (cows ha^{-1}) 2.0	3.5	2.0	3.5	2.0	SE
Summer	Crude protein (% DM)					
Grass leaf	13.8	15.3	14.6	15.4	15.0	0.5
Grass stem	3.6	4.4	4.0	4.4	4.8	0.3
Legume					17.3	
Winter						
Grass leaf	17.4	19.4	19.9	21.2	16.9	1.0
Grass stem	5.7	7.1	7.9	9.0	5.7	0.6
Legume					15.6	
Summer	IVDMD					
Grass leaf	0.63	0.64	0.59	0.61	0.58	0.01
Grass stem	0.52	0.52	0.45	0.51	0.52	0.01
Legume					0.65	
Winter						
Grass leaf	0.61	0.68	0.65	0.69	0.66	0.03
Grass stem	0.43	0.48	0.46	0.49	0.42	0.03
Legume					0.61	

* Grass-legume pastures

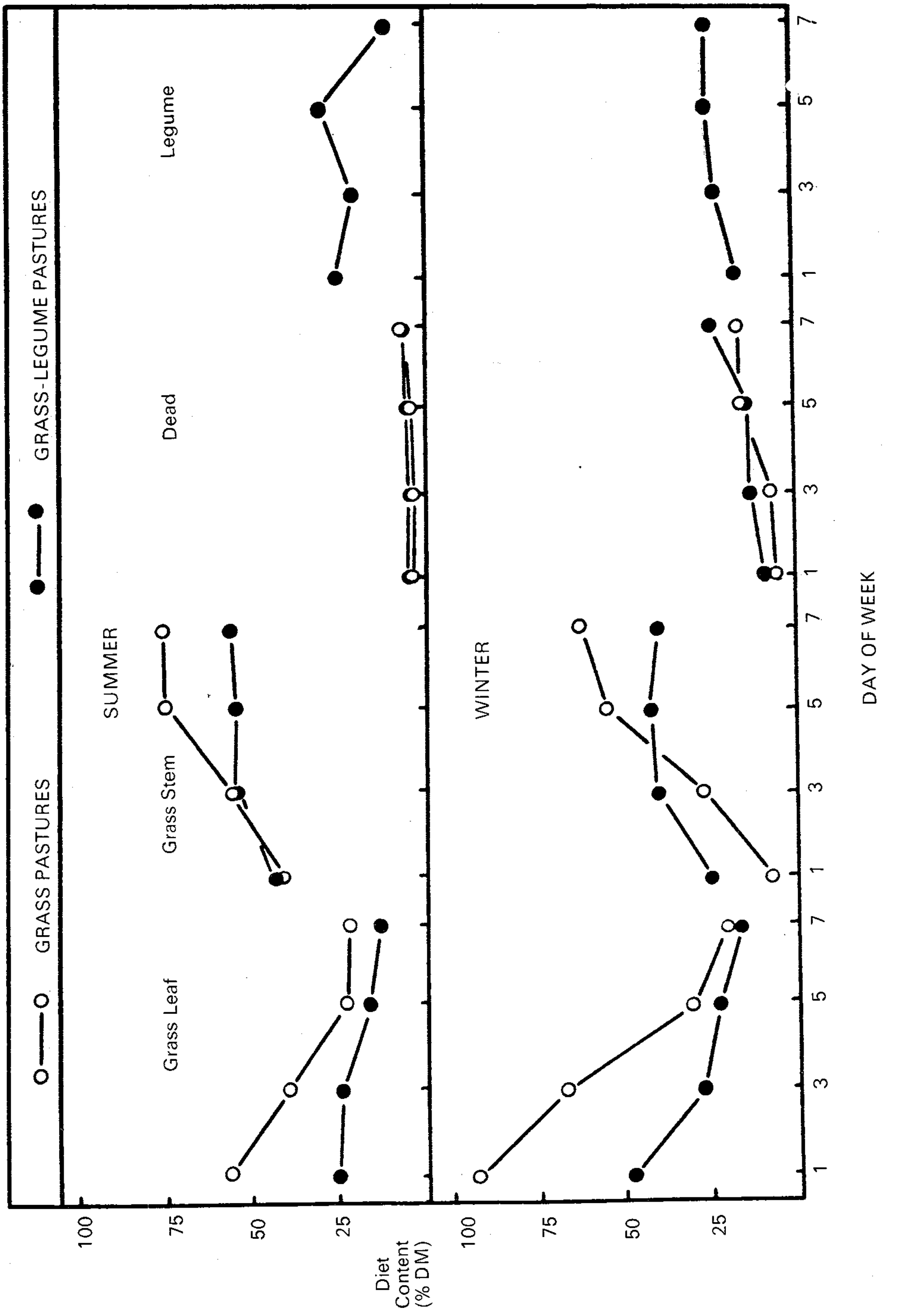

FIGURE 1
Changes during the week of grazing in the leaf, stem, dead and legume content of the diet of cows grazing grass and grass-legume pastures during summer and winter.

Diet selection

On the first day of the rotation the diet of cows grazing grass pastures had a high leaf content, a low stem content and a very low content of dead grass (Fig. 1). The content of leaf in the diet was higher in winter than in summer. As the plots were grazed down there were large reductions in proportion of leaf in the diet and corresponding increases in the content of stem and dead material. This decrease was associated with a fall in the yield of leaf on offer (Fig. 2). By contrast the changes in the composition of the diet selected by cows grazing grass-legume pastures were relatively small (Fig. 1). The proportion of grass leaf selected was relatively low early in the week, and was reduced less markedly during the week. Legume averaged about 20% of the diet throughout the week. Crude protein and IVDMD contents of the diet declined substantially during the week for cows on both pasture types (Fig. 3).

The effects of nitrogen level and stocking rate on the composition of the diet of cows grazing the pure grass pastures were relatively small compared with effect of day of the week. The important differences were (a) the leaf content selected at the beginning of grazing in summer was 49% and 65% for 2.0 and 3.5 cow ha^{-1} respectively ($P < 0.05$), (b) the leaf content selected on days 5 and 7 in winter was 38% for cows at 2.0 ha^{-1} (400 kg N ha^{-1} $year^{-1}$), and only 13% for cows at 3.5 ha^{-1} (200 kg N ha^{-1} $year^{-1}$) ($P < 0.01$), and (c) the protein and IVDMD contents of the diet on days 5 and 7 in winter were 11% and 0.46 respectively for cows at 2.0 ha^{-1} (400 kg N ha^{-1} $year^{-1}$) and 8% and 0.40 respectively for cows on other treatments ($P < 0.05$).

Grazing time

Grazing time was highest on days 2, 3 and 4 and lowest on days 5, 6 and 7 ($P < 0.05$). The relationship between grazing time for cows on pure grass pastures and yield of green leaf on offer was described by the equation below and is shown in Figure 4.

$$Y = 172 + 664X - 255X^2$$

$$(n = 12;\ R^2 = 0.58;\ SE_{b1} = 278;\ SE_{b2} = 161)$$

where Y = grazing time (min day^{-1} cow^{-1}) and X = leaf yield (t DM ha^{-1}).

Milk yield

Average milk yields were at a maximum on days 2 and 3 of each week, then declined by up to 2 kg cow^{-1} over the following 5 days (Fig. 5).

DISCUSSION

This study has shown that where cattle are rotationally grazed on tropical grass pastures, there are severe restrictions on leaf and protein content of the diet during the latter part of a weekly grazing period. Although at times there were obvious visual differences among pastures in the amount of leaf, particularly when comparing summer with winter, these differences were largely removed within 3 days of grazing, and thereafter all animals consumed a high proportion of stem in the diet. With the grass pastures, for approximately half of each grazing period the selected diet contained less than 14% crude protein although 200 or 400 kg N ha^{-1} $year^{-1}$ had been applied. These changes in diet composition are consistent with those reported for beef cattle grazing *Setaria anceps* cv. Kazangula pastures (Chacon and Stobbs 1976), though the higher nutrient demand of the dairy cow means that they are more likely to influence production.

On the mixed pastures, the proportion of legume in the selected diet was relatively constant, a result in contrast to the proportion of leaf selected in the pure grass pastures. This indicates that the system of grazing may not have a strong influence on the pattern of defoliation of these legumes. The extent of defoliation of the legume was directly related to defoliation of the total pasture, supporting previous suggestions that stocking rate is the dominant influence on legume content of these pastures (Jones 1974; Cowan, Byford and Stobbs 1975). Stobbs (1977) found there were seasonal differences in the preferences for legume and grass when offered in pens. This contrasts

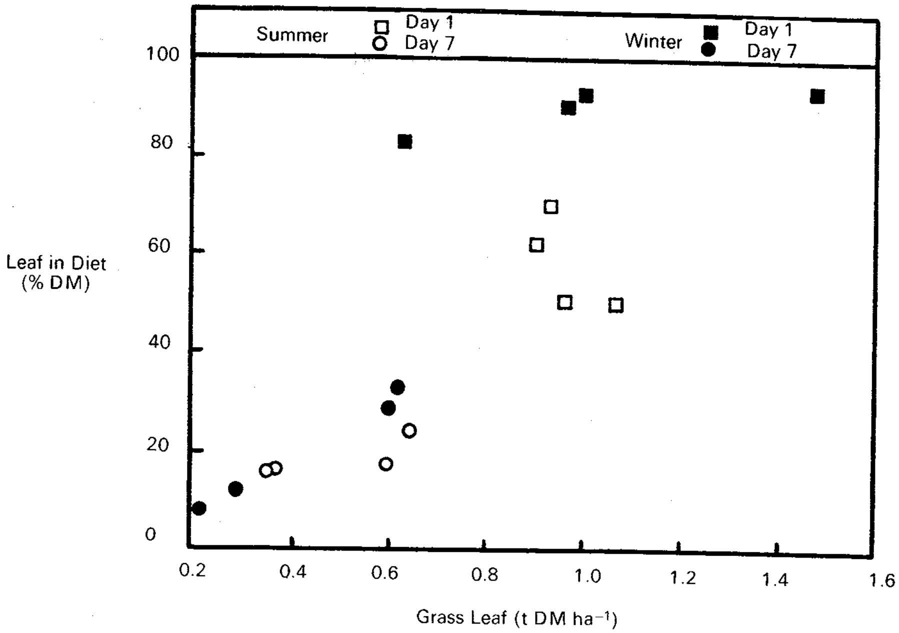

FIGURE 2
The relationship between the grass leaf percentage in the diet and the weight of grass leaf on offer in grass pastures.

with the present results, but it is likely these preferences are much less evident in the grazing situation where the species grow intermingled and factors other than preference affect grazing behaviour.

The consistent legume content in the diet meant there was less fluctuation in nutrient composition and this was confirmed by the smaller variation in milk yield for cows grazing grass-legume rather than pure grass pastures. This lack of within-week variation in nutrition may partly explain the higher milk yields of cows grazing grass-legume pastures (Davison and Cowan 1978) in addition to a direct effect of the presence of a legume increasing dry matter intake and animal production (Evans 1970; Hamilton *et al.* 1970).

This study was conducted over a relatively short period of time and the results cannot be used to predict the long term effects of grazing on either the pastures or the cattle. However there is a close association between mean diet composition in this study and the diet composition and milk production measured over 3 years for grass pastures (Davison *et al.* 1985). Both the short and long term results indicate the importance of yield of grass leaf for high milk production from pure grass pastures, and as in previous studies (Chacon and Stobbs 1976; Davison *et al.* 1981) it is concluded that decisions on pasture management should not be made on the basis of total yield of a pasture, but rather on an assessment of leaf yield.

The grazing times recorded support previous observations that grazing time is reduced when yield of pasture is very low (Cowan 1975; Cowan and O'Grady 1976). Since the rate of prehension also falls with reducing yield of green pasture (Chacon and Stobbs 1976), the reduced grazing time would be associated with a disproportionately large decrease in pasture intake. The data suggest grazing time is at a maximum when leaf yield is approximately 1.0 t DM ha^{-1}, similar to the leaf yield associated with maximum grazing times for grazing the legume *Lab lab purpureus* (Hendrickson and Minson 1980), and is reduced by yields of leaf on offer below this value.

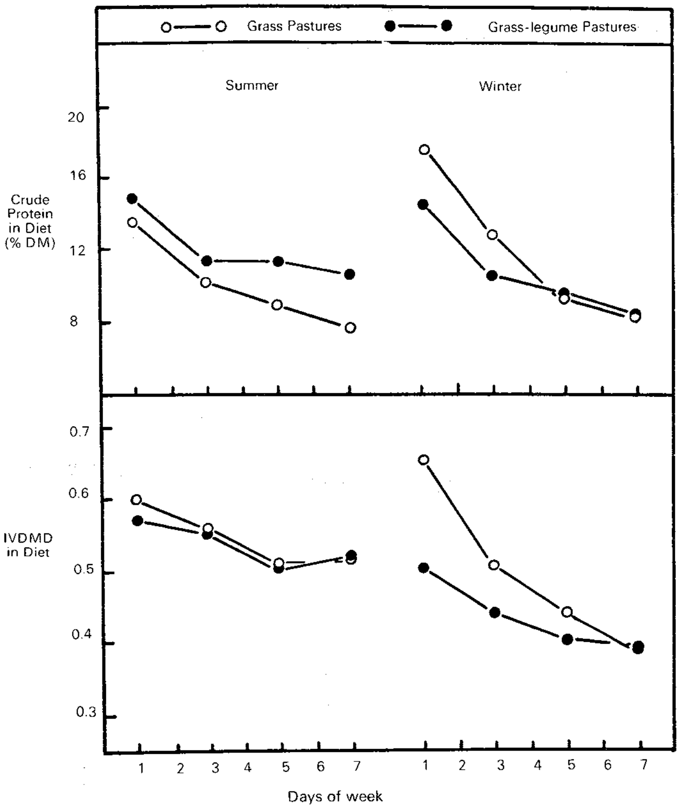

FIGURE 3

Changes during the week in the crude protein and IVDMD content of the diet of cows grazing grass and grass-legume pastures during summer and winter.

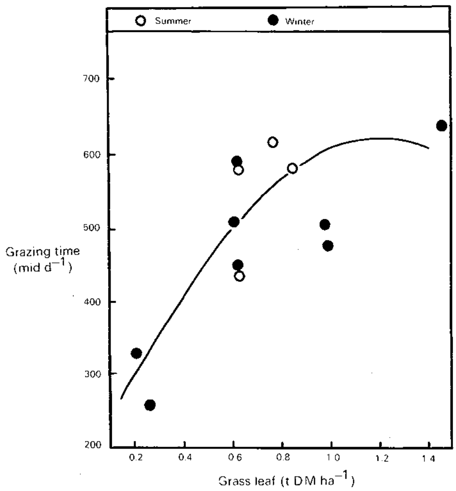

FIGURE 4

The relationship of grazing time to yield of grass leaf. The fitted line is described in the text.

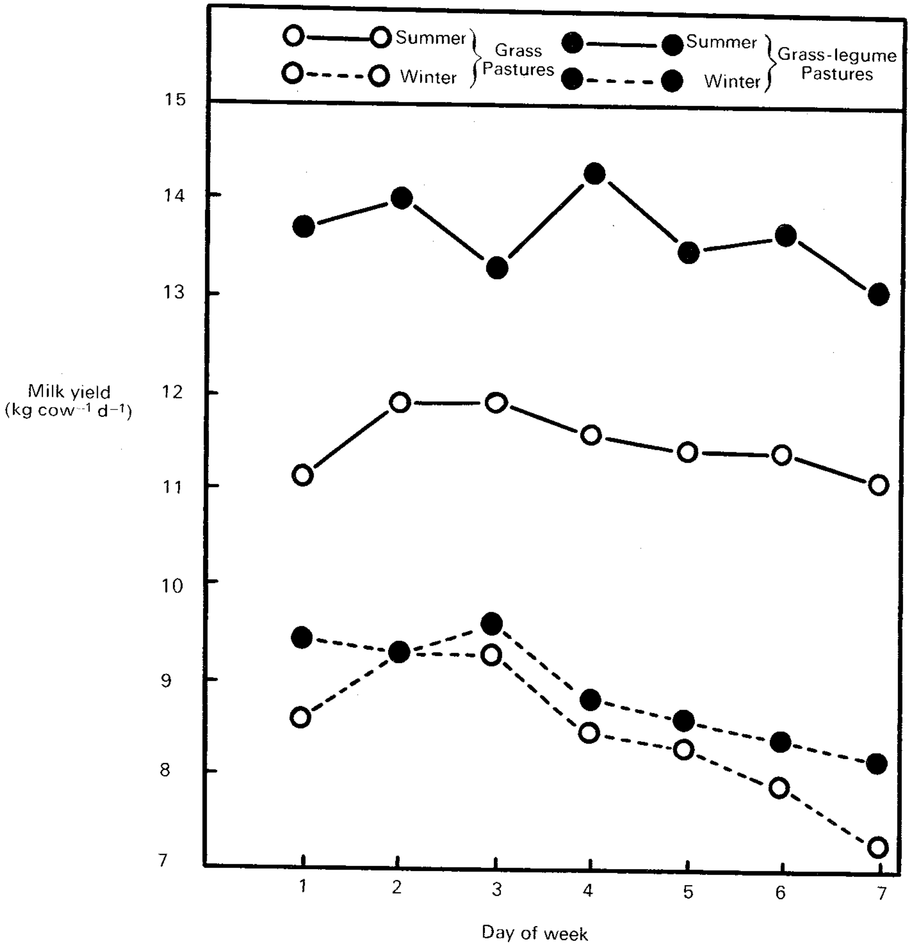

FIGURE 5
Changes in milk yield of cows during the week.

CONCLUSION

With rotational grazing cows select a more consistent diet from grass-legume pastures than from pure grass pastures. For pure grass pastures selection of leaf is critical in maintaining high diet quality and milk production. Leaf selection is very high early in the grazing period but falls rapidly. It was concluded that because of the strong influence of leaf selection from pure grass pastures on diet quality and milk production, assessments of grazing management should be made on the basis of leaf yield.

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