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Seasonal variations in pasture quality on New Zealand sheep and beef farms

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ABSTRACT

Nineteen sheep and beef farmers in the Waikato, Tararua, Canterbury and Southland regions collected two pre-grazing pasture samples offered to either lambs or bulls once every month from autumn 2000 to autumn 2001. One sample of pasture on offer was collected to ground level and the other was hand plucked to represent pasture selected by animals. The samples were analysed by NIRS for chemical composition and dissected into morphological components. Energy concentration of herbage was lowest in autumn and highest in spring. Energy concentrations of offered pasture were 8.1, 9.2, 7.6 and 10.0 MJME/kg DM in autumn and 10.3, 11.6, 10.8 and 11.4 MJME/kg DM in spring in Waikato, Tararua, Canterbury and Southland, respectively. Crude-protein, fibre and soluble-carbohydrate concentrations reflected the changes in ME. Variations in dead material and reproductive stem were the main causes of changes in ME. Predicted liveweight gain of 350-kg bulls grazing pasture with a pre- and post-grazing herbage mass of 2500 and 1500 kgDM/ha respectively, were 0.4, 0.8, 0.0, and 1.1 kg/d in autumn, and 1.2, 1.5, 1.4 and 1.6 kg/d in spring, for Waikato, Tararua, Canterbury and Southland regions, respectively. It is concluded that high animal performance in summer and autumn may not be achieved in summer-warm regions without the addition of high-quality forages or supplements.

Keywords: pasture; metabolisable energy; crude protein; farm; sheep; cattle; seasonal pattern.

INTRODUCTION

Livestock nutrition has traditionally been manipulated by changing the quantity of feed offered (Milligan *et al*., 1987). Because of this, farm systems have been customised to match seasonal pasture growth patterns with animal dry-matter (DM) demands. However, at critical times of the year, providing an adequate quantity of pasture may not be sufficient to ensure high animal performance because pasture quality imposes a limit to potential liveweight gain (Poppi *et al*., 1987). In such cases, pasture quality must also be considered when planning feeding of animals. No systematic information currently exists for pasture quality on commercial sheep and beef farms across regions. This paper describes the seasonal patterns of pasture energy and chemical composition changes during one year on 19 commercial sheep and beef farms in four regions of New Zealand. Pasture quality is quantified in terms of pasture composition, metabolisable energy (ME), crude protein (CP), carbohydrate (CHO), lipid, and fibre contents. The Q-Graze model (Woodward *et al*., 2000) was used to integrate seasonal differences in pasture quality and pre- and post-grazing herbage masses to predict the liveweight gain of growing beef cattle. Possible limitations of these pastures in terms of dietary balance are briefly discussed.

MATERIALS AND METHODS

Four mentor groups of sheep and beef farmers were established to assist Meat New Zealand to develop an on-farm eye-assessment system to quantify pasture quality. A subset of these farmers in the Waikato (including Waikato and King Country, n=4), Tararua (including Tararua, Manawatu and Wairarapa, n=5), Canterbury (n=5) and Southland (n=5) regions collected two pre-grazing pasture samples by walking across a paddock and taking a sample every three steps for a minimum of 100 sampling sites. This sample regimen was derived to estimate the ME of the pasture to within 0.2 MJME/kgDM (Cosgrove *et al*., 1998). Pasture was collected from in front of one mob of either growing lambs (Southland, Canterbury plus two Tararua farms) or bulls (Waikato and three Tararua farms) once every month from autumn 2000 to autumn 2001. One pasture sample was cut to ground level ("offered pasture") and the other plucked by the farmers to represent the pasture selected by animals ("plucked pasture"). Farmers were initially trained in the pasture-collection method and, thereafter, they collected the pasture samples unsupervised.

Immediately after collection, the samples were microwaved on full power for one minute to arrest respiration and then stored in a fridge until posted to AgResearch Grasslands, Palmerston North (time from posting to arrival was two to three days). On arrival, the samples were thoroughly mixed and sub-sampled by quartering. One sub-sample was dissected into four categories: dead matter, green clover plus herbs ("clover"), green grass leaf, and green grass flowering stem plus low-quality weeds ("stem"). The pasture components were dried (60 °C, forced-air oven) and weighed to determine pasture DM composition on a total DM basis. Another sub-sample was dried (60°C, forced air oven) and ground (1mm sieve) and the chemical composition (ME, CP, CHO, ash, acid detergent fibre (ADF), neutral detergent fibre (NDF) and lipid) was determined by near infrared spectroscopy (Corson *et al*., 1999) by feedTECH, Palmerston North.

The farmers also visually assessed the paddock herbage mass, and the residual herbage mass after the previous grazing. The Q-Graze model was used to predict liveweight gain of 350-kg Friesian bulls in each month for either the actual pre- and post-grazing masses or for standard pre- and post-grazing herbage masses of 2500 and 1500 kgDM/ha.

The pasture quality data were grouped into three-month seasons for statistical analysis, summer defined as December, January and February; autumn as March, April and May; winter as June, July, and August; and spring as September, October, and November. Data were analysed using the general linear model (SAS, 1990) and analysed for effects of region and season.

RESULTS

Regions: The average energy content of offered pasture (Table 1) was highest on Southland farms, intermediate on Tararua farms and lowest on Waikato and Canterbury farms. The ME concentration of hand-plucked pasture (Table 2) was similar on farms in Southland and Tararua and lower on farms in Waikato and Canterbury. Acid-detergent-fibre and neutral- detergent-fibre concentrations followed the pattern of ME concentrations across the regions (Table 1, 2). Crude-protein concentrations were highest on Southland farms, intermediate on farms in Tararua and Waikato, and lowest on Canterbury farms in pastures offered (Table 1) and hand-plucked (Table 2). Soluble-carbohydrate concentrations were highest in pastures on Tararua farms, intermediate on Canterbury and Southland farms and lowest in pastures on farms in Waikato (Table 1, 2). Samples plucked to simulate animal diet selection tended to have more-favourable chemical composition than those offered.

The pastures on Southland farms had the lowest dead matter, while pastures on Canterbury and Tararua farms had moderate levels of dead matter and the Waikato had farms with higher dead-matter (Table 1). Pastures on Canterbury farms had the highest content of green reproductive stem (Table 1), while Waikato and Southland farms were intermediate and Tararua farms the lowest. The clover content of offered pasture was lowest on Southland farms, intermediate on Canterbury and Tararua farms, and highest on Waikato farms (Table 1).

The average annual predicted liveweight gain for these pastures if grazed from 2500 to 1500 kgDM/ha over 12 months was 1.3, 1.2, 0.8 and 0.9 kg/d for Southland, Tararua, Waikato and Canterbury farms, respectively.

Seasonal trends: Energy concentration (ME) of herbage followed similar seasonal trends (Figure 1) in all regions, being lowest in autumn and highest in spring for both pasture on offer (Table 1) and plucked (Table 2). There was a trend (P<0.10) for the decrease in pasture quality in Southland farms between spring and autumn to be smaller than that on farms in Waikato and Tararua, which was in turn smaller than the decrease on farms in Canterbury.

TABLE 1: Chemical and botanical composition (remainder is green grass leaf) of offered pasture collected from commercial sheep and beef farms in four regions and predicted liveweight gain using Q-Graze.

	ME (MJME/kgDM)	CP	ADF	NDF (%DM)	CHO	Dead	Clover	Stem	LWG[1] (kg/d)	LWG[2]
Waikato										
Sum	8.5	17.7	32	55	5.3	24	17	15	0.6	0.5
Aut	8.1	18.8	33	57	6.3	29	10	19	0.3	0.4
Win	9.8	24.2	22	49	7.9	21	13	0	0.8	1.2
Spr	10.3	22.6	28	50	7.1	15	16	2	0.7	1.2
Mean	**9.2**	**20.8**	**30**	**53**	**6.6**	**22**	**14**	**9**	**0.6**	**0.8**
Tararua										
Sum	10.0	18.1	27	47	10.6	11	14	6	0.8	1.0
Aut	9.2	21.9	30	50	7.7	25	10	0	0.7	0.8
Win	10.6	23.3	26	48	10.1	12	6	0	1.1	1.4
Spr	11.6	24.4	22	42	12.1	6	6	0	1.3	1.5
Mean	**10.3**	**21.8**	**26**	**47**	**10.1**	**14**	**9**	**2**	**1.0**	**1.2**
Canterbury										
Sum	9.0	20.2	29	51	6.0	10	18	19	0.5	0.9
Aut	7.6	13.9	33	57	6.5	13	5	39	-0.7	0.0
Win	9.5	19.9	26	49	12.4	21	4	0	1.0	1.3
Spr	10.8	21.5	29	43	11.4	9	13	1	1.1	1.4
Mean	**9.2**	**18.9**	**28**	**50**	**9.1**	**13**	**10**	**15**	**0.5**	**0.9**
Southland										
Sum	10.0	19.7	27	51	7.5	11	14	10	1.0	1.2
Aut	10.0	20.3	28	52	6.8	10	10	10	0.5	1.1
Win	11.3	27.4	25	46	8.8	8	6	5	1.0	1.5
Spr	11.4	24.4	23	44	10.2	6	6	1	1.3	1.6
Mean	**10.7**	**22.9**	**25**	**48**	**8.3**	**9**	**7**	**6**	**0.9**	**1.3**
SED	0.4	1.8	1.5	2.5	1.1	4.8	3.5	5.0		
Significance										
Region	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001		
Season	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001		
Region*Season	0.09	0.02	0.30	0.30	0.004	0.13	0.08	0.001		

Seasons: Sum - summer; Aut - autumn; Win - winter; Spr - spring

Parameters: ME - metabolisable energy; CP - crude protein; ADF - acid detergent fibre; NDF - neutral detergent fibre; CHO - soluble carbohydrate.

LWG[1] Predicted liveweight gain of 350 kg Friesian bulls grazing paddocks using pre- and post-grazing residuals from Table 2.

LWG[2] Predicted liveweight gain of 350 kg Friesian bulls grazing paddocks from a pre-grazing mass of 2500 down to a residual of 1500 kg DM/ha.

Protein concentration of offered (Table 1) and plucked pasture (Table 2) was lower in summer and autumn than in spring and winter. A significant interaction between region and season occurred as CP concentration increased from summer through autumn to peak in winter in pastures on farms in Waikato, Tararua and Southland, but declined into autumn, before increasing on farms in Canterbury (Tables 1, 2). Only 4% of individual plucked pasture samples contained less than 15% CP at which animal growth may be affected. These pastures occurred only in Canterbury and Tararua from January to April and were associated with low ME concentration.

Mean dietary NDF concentrations (predominantly cellulose, hemicellulose and lignin), followed a similar pattern to that of ME throughout the seasons (Table 1, 2). Relative to NDF, the fluctuations in ADF (predominantly cellulose and lignin) between seasons were smaller (Tables 1, 2) but were still higher in summer and autumn than in winter and spring. There was a seasonal cycle in CHO (Tables 1, 2; Figure 2), as concentrations were low in summer and autumn and higher in winter and spring. Regions responded differently with season (Table 1, 2). The lipid content of pastures were higher in spring (5.6%) and winter (5.3%) relative to summer (5.2%) and autumn (4.9%).

Overall, the offered pastures contained approximately 10% clover, summer pastures containing 16% clover and winter pastures 6% clover (Table 1). The proportion of clover in plucked herbage averaged 16%, reaching a peak of 22% in summer and a nadir of 8% in winter. Dead matter content peaked during autumn and was lowest in spring pastures (Table 1). The amount of reproductive stem offered in pasture was the most variable morphological component (Table 1). This produced a significant interaction between region and season. Pastures on Canterbury farms had the greatest reproductive stem content in summer and autumn, though no different from Waikato in summer. Pasture in all regions had very low reproductive stem contents in winter and spring. Pastures on Tararua farms had the lowest reproductive stem contents in all seasons.

When grazing pastures from 2500 down to 1500 kg DM/ha, the quality of Southland farm pastures was such that predicted bull liveweight gains were in excess of 1 kg/d all year round (Table 1). In contrast, in the Waikato, low pasture quality in summer and autumn limited potential bull liveweight gain to less than 0.5 kg/d. Even when grazed optimally, the very stemmy pastures in Canterbury were only maintained bull liveweight over summer and autumn (Table 1). When actual rather than optimum pasture masses were used, potential LWG of bulls over winter and spring was limited by low herbage mass rather than pasture quality (Table 1).

TABLE 2: Pre-grazing herbage mass (PreHM), days since last grazed, post-grazing herbage mass (PostHM) and chemical composition of pasture plucked to simulate animal diet selection on commercial sheep and beef farms in four regions.

	PreHM (kgDM/ha)	Days	PostHM (kgDM/ha)	ME (MJME /kgDM)	CP	ADF	NDF	CHO
						(% DM)		
Waikato								
Sum	2200	23	1800	9.0	21	28	49	6.5
Aut	2060	25	1500	9.1	23	27	48	7.2
Win	1660	31	1160	10.9	28	22	44	9.0
Spr	1600	25	1060	11.1	27	23	45	7.8
Mean	**1870**	**26**	**1390**	**10.1**	**25**	**25**	**47**	**7.6**
Tararua								
Sum	1930	24	1340	10.7	23	25	42	11.6
Aut	1950	30	1380	10.1	25	23	44	7.7
Win	1930	48	1244	10.9	26	22	44	11.0
Spr	1780	23	1200	11.5	27	21	39	13.0
Mean	**1900**	**31**	**1300**	**10.9**	**25**	**22**	**42**	**10.8**
Canterbury								
Sum	1970	27	1300	9.4	24	26	46	6.3
Aut	1960	35	1170	8.1	17	29	53	6.9
Win	1900	69	1300	10.3	21	23	44	12.5
Spr	1800	29	1100	11.3	25	21	38	11.9
Mean	**1910**	**40**	**1220**	**9.8**	**22**	**25**	**46**	**9.4**
Southland								
Sum	2290	24	1110	10.6	23	25	47	7.5
Aut	1980	24	830	11.0	26	23	44	8.4
Win	1680	57	1030	11.2	27	22	46	8.3
Spr	1840	41	1200	11.5	27	21	41	10.3
Mean	**1950**	**36**	**970**	**11.1**	**26**	**22.7**	**44**	**8.6**
SED	230	8	165	0.4	1.7	1.5	2.4	1.2
Significance								
Region	0.9	0.02	0.003	0.001	0.001	0.003	0.004	0.001
Season	0.005	0.001	0.009	0.001	0.001	0.001	0.001	0.001
Region*Season	0.70	0.11	0.22	0.002	0.002	0.06	0.01	0.003

Seasons: Sum summer; Aut autumn; Win winter; Spr spring

Parameters: ME - metabolisable energy; CP - crude protein; ADF - acid detergent fibre; NDF - neutral detergent fibre; CHO - soluble carbohydrate.

FIGURE 1. Seasonal pattern of offered pasture composition (dead, clover + herbs, green grass leaf, green grass reproductive stem) and energy (ME) content on commercial sheep and beef farms in four regions

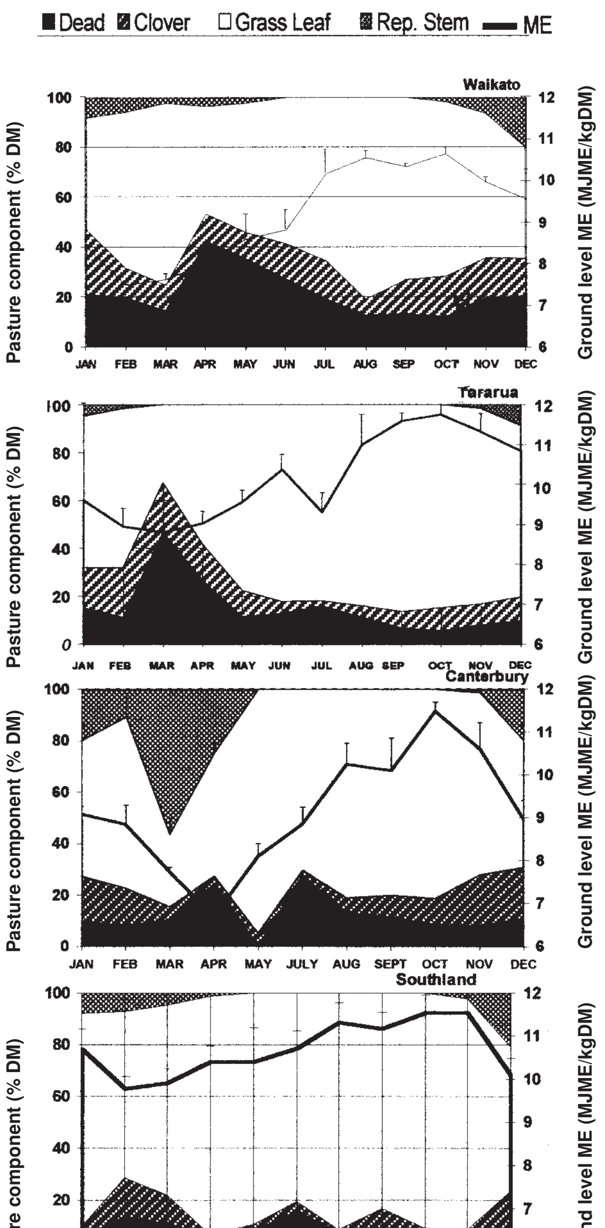
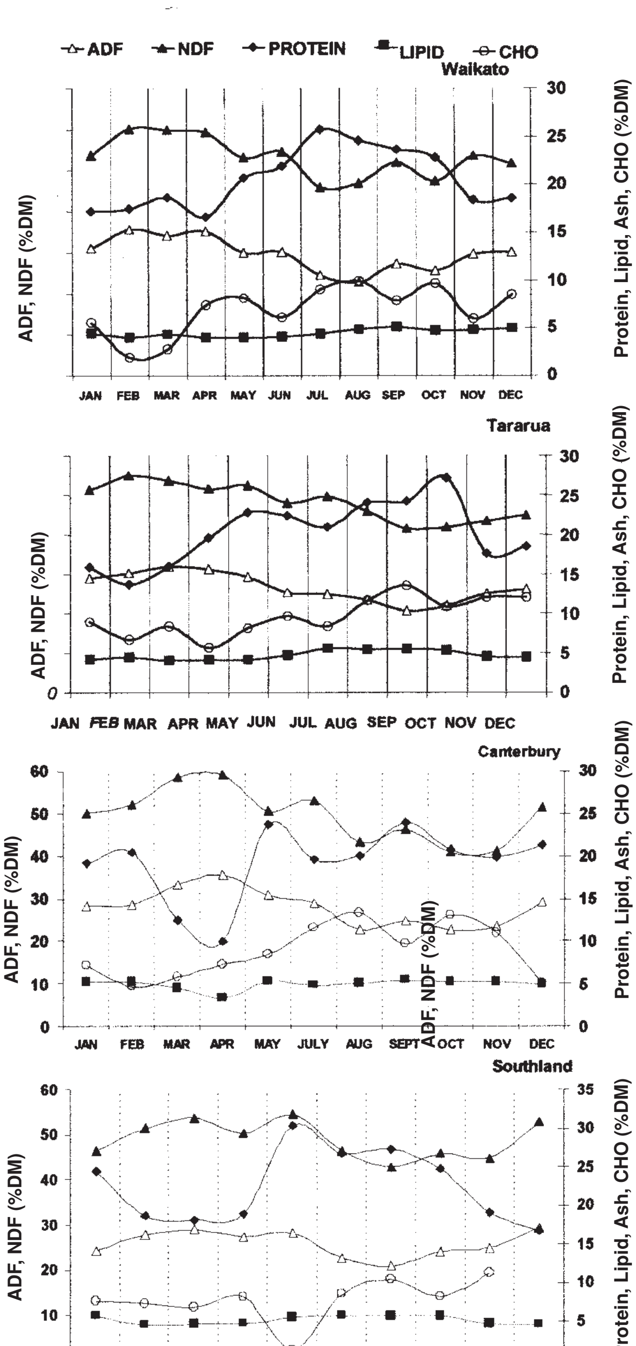


FIGURE 2. Seasonal pattern of chemical composition of pasture plucked to simulate animal intake on commercial sheep and beef farms in four regions.



DISCUSSION

ME content of pastures was highly seasonal, especially in Northerly regions. Pasture energy levels declined after November, as dead matter and stem content increased, reaching a nadir in autumn. ME concentrations increased during winter to reach a peak in spring. The quality of sheep and beef pastures in this survey followed a similar seasonal pattern to those reported for dairy (Moller *et al*., 1996a), sheep (Rattray, 1977; Clark *et al*., 1982) and bull (Clark & Brougham, 1979) pastures. This study only reports pasture quality for one year and variations in climate will affect the magnitude of pasture quality changes between years. Clark & Brougham (1979) recorded pasture quality in highly stocked bull pastures in Manawatu over two years and found that the autumn nadir was 9 in the first and 10 MJME/kg DM in the second year but in both years the winter and spring pastures were reliably above 11 MJME/kg DM.

The decline in ME in summer was associated with an increase in dead matter accumulation. Dead matter accumulates when the senescence rate rises at high temperatures and the rate of breakdown of senescent tissue slows in dry conditions (Woodward, 1998). Increasing photoperiod in late spring triggers reproductive grass growth which if left uncontrolled, can lead to a residue of low-quality stem material in autumn that further lowers ME (Waghorn & Barry, 1987). The particularly low ME values recorded in this study in Canterbury in autumn were associated with excessive stem content.

The quality of green grass leaf is also lower in autumn then in spring. It is well established that grass leaves growing at high temperature have higher fibre content and lower digestibility than leaves of the same maturity growing at low temperature (Wilson & Ford, 1973; Fales, 1986). For example, Wilson & Ford (1973) recorded a drop of 1 MJME/kg DM in temperate grass leaf grown at 30°C compared with leaves grown at 20°C.

In warmer locations, such as Waikato, high bull LWGs cannot be achieved in summer and autumn due to the low ME concentration of perennial grass swards at that time. In those environments, high bull LWG will only be possible on specialist non grass swards such as chicory or on high-clover swards. However, in this study the overall average clover content of pastures was only 10% and the clover content of the diet was estimated to be 16%. This highlights the relatively low proportion of clover in the diet of growing stock grazing perennial grass/ clover swards on commercial sheep and beef farms. Conversely, cooler, moist environments like that of Southland have potential for growing stock over summer and autumn. All regions can reliably grow bulls fast over winter providing they can offer adequate quantities of pasture.

The dietary CP requirement of growing cattle is 12-15% (National Research Council (NRC), 1996). Concentrations of protein in the pasture in this study and in that of Clark & Brougham (1979) were, in most instances, surplus to that required by the animal.

Mean dietary NDF values exceeded recommended levels of 35% (NRC, 1996) in short pastures in 99.6% of plucked herbage samples, indicating that voluntary feed intake was not limited by low fibre content. The CHO contents of the pastures were lower in summer/autumn and higher in winter, similar to the variation found by Metson & Saunders, (1978).

Moller *et al*. (1996b) proposed that a dietary imbalance occurs in early spring in dairy cows when they consume low fibre, low CHO and high protein pasture and that this impairs animal performance. Our study suggests that perennial grass swards only rarely contain low concentration of fibre, but often contain low concentrations of CHO and high concentrations of protein. The impact of this condition on sheep and beef farms has yet to be studied.

Results from this study showed that sheep and beef pastures were rarely deficient in protein or fibre. Low energy content of pasture in summer and autumn was caused by high dead matter and reproductive stem content. This is likely to be the main limitation to animal performance, especially in regions where summer temperature is high.

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