SEASONAL LIMITATIONS TO NUTRITION OF SHEEP AND BEEF CATTLE IN HIGH RAINFALL AREAS OF SOUTH-EASTERN AUSTRALIA

INTRODUCTION

P.R. BIRD*

The cattle and sheep industries of Australia are almost entirely dependent on grazing animals. Weston and Hogan (1973) estimated that less than 5% of the feed consumed by domestic ruminants in this country is derived from sown grain crops, and only 5 or 6% from conserved forage. Consequently effective management and use of pastures are of prime importance for efficient animal production. Although the high rainfall zone of southern Australia is smaller than the wheat-sheep and pastoral zones, it carries a disproportionately high percentage of the sheep (about 33%) and cattle population. The ability of pasture in this zone to provide adequate nutrition for grazing animals varies during the year and has been the subject of research at various centres. In the following papers we have concentrated on our own work in the Western District of Victoria because the range of environments found within the high rainfall zone is extremely diverse and cannot adequately be dealt with here. The initial paper gives a general overview of the pasture limitations to nutrition of grazing animals and the following one deals with seasonal variation in the most common pasture species of the area, and production from weaner sheep grazing a subclover pasture in the dry summer-autumn period. The other contributions describe three managemental approaches which may reduce or eliminate the commonly experienced seasonal limitations to ruminant nutrition and consequent animal production. These are:- the continued use of superphosphate to maintain wool growth in grazing sheep, particularly in autumn and winter; the potential of different pasture legumes to maintain a satisfactory voluntary intake of ruminants during summer-autumn dry periods and the scope for using grain or proteins to supplement the diet of grazing animals at times of pasture inadequacy.

SEASONAL LIMITATIONS TO THE NUTRITION OF SHEEP AND BEEF CATTLE IN THE HIGH RAINFALL AREAS OF SOUTH-EASTERN AUSTRALIA

H.A. BIRRELL*, K.F.M. REED* and P.R. BIRD*

REGIONS IN THE HIGH RAINFALL AREAS

Much of the land in south-eastern Australia, including southern Victoria, Tasmania and the south east regions of South Australia and New South Wales, receives more than 600 mm rainfall each year with a distribution sufficient to allow pasture at least 9 months growth. Many perennial species can survive the 10-12 weeks of hot, dry summer and start to grow again when soil moisture is replenished by autumn rains. Obvious differences occur between districts in climate, soil type and topography, and these have a substantial effect on the pasture types and hence management options including the livestock enterprise. Even within regions there are adaptations of pasture type to favourable environments. For example, East Gippsland often suffers from prolonged dry periods due in part to a rain shadow caused by air currents lifting over the Great Dividing Range, whereas the hills of West Gippsland are almost always green with a rainfall 63% higher than the Western District (1100 mm vs 680 mm).

Seasonal conditions between districts need only be small to have a large impact on the annual pasture cycle, for instance the mean winter temperature

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{(maximum + minimum)/2} along the coastal areas nearly always fluctuates around 12° C in the July to August period, but 50 miles inland it is almost 3° C lower. The growth of pasture in winter in the hinterland area, < 20 kg dry matter (DM)/ha /d, is inhibited by these low temperatures. The recognition of differing environmental limitations between districts may be worthwhile when considering the development of cultivars suitable for these areas.

SEASONAL LIMITATIONS

Most of the comments in this paper are related to experience within the Western District of Victoria. However, in the broad context many of the principles may be extrapolated to the whole high rainfall area. The factors which are considered important in the different periods of the year are discussed.

Late autumn-winter-early spring

In most years adequate rain early in autumn (i.e. by late March and defined as $P/E^{0.75} > 1.2$ where P (mm) is precipitation and E (mm) is pan evaporation) is then followed by rain at regular intervals which usually ensures that the growth of improved pasture is sufficient to maintain availability at 0.7 to 0.8 tonne DM/ha when stocked at 15 to 20 dry sheep/ha. This will not severely penalise the performance of these animals throughout the autumn and winter. Only in the severe winters, when the opening rains are late or a prolonged cold, wet period is experienced, is it likely that a management strategy such as supplementation (hay and oats) will be beneficial. Corah and Bishop (1973) and Gillespie and McLaughlin (1977) have found that young sheep grazing winter pasture (12 sheep/ha) where the yield is approximately 1.4 t DM/ha gained more weight over winter/early spring than similar groups in feedlots given ad *libitum* rations of good quality hay and oats. Supplementing grazing sheep with oats to increase liveweight gain during the autumn-winter months has also been shown to be ineffective (Egan and Learmonth 1978), although it can be a valuable feed for survival if there is a lot of animals on hand and the pasture present falls to very low levels (e.g. 0.3 t DM/ha) (Reed 1972c).

Wool growth responses have been found to be sensitive to management practices such as stocking rate, fodder conservation and grazing method over the autumn and winter period (Birrell et *al.* 1978). Increasing stocking rate depresses the yield of pasture, hence stocking rate shows up as the major determinant. The effects of making and feeding of hay are complex and observed responses have been variable. The value of hay for survival purposes cannot be disputed, especially with high stocking when feed shortages are more likely. In most years however, wool production does not respond to hay feeding. Birrell and Bishop (1980) have shown gains in annual wool production to hay feeding when autumn rains are late but only at a stocking rate just below that found for optimum production (i.e. 15 sheep/ha). Possibly the substitution of hay for pasture at such stocking enables sufficient pasture to accumulate and optimise leaf area for adequate self generation under thelighter grazing.

In autumn the quality of dry herbage may be affected by heavy rains causing leaching of soluble nutrients. However, despite the vagaries of the weather, the quality of the diet selected by animals can be partially controlled by ensuring that the green component is freely accessible and not overburdened with residues from the previous season. Birrell (1978) showed that the organic matter digestibility of pasture selected by sheep in autumn and early winter can be depressed by up to ten units by residue of pasture from the previous year. Wool production and live weight were also increased when large amounts of spring herbage were removed from the grazing system (Birrell and Bishop 1980). Thus it appears that access to the green herbage specially in a mixed species. pasture is an important determinant of animal response. At low stocking rates it is common for dry residues from the previous spring to form 50% or more of the pasture available. Dilution of the green sward by dead material at Hamilton (Watson *et al.* 1979) has been shown to hamper the performance of grazing steers. An expression for autumn was: $ADG = -2713 + 1.7\ G + 7.5\sqrt{G} - 0.8D + 97\sqrt{D} - 1.0\sqrt{G} \times \sqrt{D}$ (R^2 0.51, RSD 328) where ADG is average daily gain (g), G is green herbage (kg DM/ha and D is dead herbage (kg DM/ha). This shows that pasture containing the same amount of green DM/ha in the autumn period has a greater weight loss when the dead component is 4-5 t/ha than with 2-3 t/ha. Dilution of the green fraction with less digestible dry residues results in a decreased intake of digestible energy; the steer clearly cannot cope by selecting sufficient green pasture.

A similar expression for the winter-early spring shows that for green pasture in excess of 1.3 t DM/ha an increasing amount of dead herbage decreases the liveweight gain of steers:

$$ADG = -4503 - 1.2\ G + 179\sqrt{G} + 56.4\sqrt{D} - 1.6\sqrt{G} \times \sqrt{D}\ (R^2 = 0.61,\ RSD\ 287).$$

Nevertheless, slow growth of pasture remains a major winter problem and has prompted a range of investigations aimed at increasing carrying capacity and/or per head performance during the periods of restriction. Deferment of grazing over autumn, especially after early season rain, has increased the growth of the perennial type pasture during winter at these grazing pressures which are slightly below the optimum stocking rates, i.e. *c.* 15 wethers/ha (Birrell *et al.* 1978). While this may be advantageous for fattening those stock which are soon to be marketed, the compensatory gains made in spring by livestock which are set-stocked throughout the year are such that the cumulative animal production results are not economically attractive (Cannon 1970; Brown 1976). Nitrogen fertilizer is sometimes used to increase winter growth on dairying pastures (Newman et *al.* 1962) but at the Pastoral Research Institute limited investigations into its use, in association with deferred grazing of beef cattle have been disappointing, despite the fact that pasture growth was increased significant weight gains were not achieved (G.R. Saul personal communication).

When temperature, day length and the daily period of direct sunlight begin to increase in mid spring, pasture growth and animal responses are at their greatest. The best responses with young growing animals have been observed when the yield of pasture present is between 1.5-2.0 t DM/ha, and when pasture growth is rapid. Bird *et al.* (1979) recorded maximum rates of liveweight gains with young steers on such pastures, and Birrell (1978)' has shown very high intakes of herbage by wethers in low condition on this type of pasture. Compensatory gains in spring made by animals whose growth is restricted during the winter vary from year to year (see Bird *et al.* 1980); the greatest compensation (55%) occurred when the spring growth season was extended by late rains. Subsequent work has shown that the degree of compensation is not substantially greater when restricted steers are transferred to lightly stocked pasture during spring (Bird unpublished), i.e. intensively grazed spring pasture can sustain intake and growth rate.

There has been heavy use made of superphosphate in the Western District of Victoria relative to other wool growing regions in the high rainfall zone of Australia (Bishop 1964). Where superphosphate is applied in autumn the relative response by pasture in autumn-winter is more than treble that in other seasons (Reed 1977). In many cases the use of superphosphate may still represent the most useful strategy for improving animal production in autumn-winter. Despite heavy use of the fertilizer in the past, analysis of 700 recent soil advisory samples (0-10 cm cores) from the Hamilton district has shown that 80% were below 10 ppm Olsen P. A wool production experiment (rates of P fertilizer by stocking rates) on a Dunkeld property (Olsen P = 8 ppm) commenced in 1975 and has shown that wethers stocked at 15/ha with no superphosphate cut 4.62 kg of greasy fleece wool (5 year average). At 21/ha with 15 kg P/ha/yr they cut 4.82 kg. The excellent wool response at this site was associated with a trebling of winter pasture growth (6.4 to 1.2 t DM/ha) (P. Schroeder and R. McKenzie personal communication).

Studies carried out in Europe, Tasmania and New Zealand and reviewed by Reed (1978) show that although autumn-saved or winter-grown grass may compare favourably with the same grass in spring in terms of digestibility, its voluntary intake value may be considerably less than in the spring. The effect is not obvious with legumes. Such changes (thought to be associated with chemical composition as influenced by day length and net radiation) may explain the rates of liveweight gain in winter which, relative to the yield of pasture present, sometimes appear low when compared with gains recorded in spring. Recent testing of pasture species in Victoria has shown that new cultivars of white clover containing material of mediterranean origin have much greater ability to grow in winter than the traditionally used cultivars. There is some evidence that perennial ryegrass could also be improved by incorporating mediterranean material (Reed, Cade and Williams 1980). The testing has also indicated that new cultivars such as Sirosa Phalaris and Trikkala subclover can out-yield the common cultivars in winter and that short-lived species such as giant shaftal clover, hybrid ryegrass and westerwolds ryegrass have the ability to out-yield the more permanent species. These could provide a more flexible winter pasture than an oat crop. Oats are sometimes sod-seeded, particularly in dairying districts, but their overall contribution is sometimes unsatisfactory (Slarke 1977).

Late spring-early summer

McLaughlin and Bishop (1969) and McLaughlin (1973) suggested that the early growth of weaner sheep was an important determinant of the long term production of the animal. The live weight of the weaner entering its first summer period appeared to be the single most important factor whereas manipulating nutrition by supplementation, although sometimes providing benefits, was found to be variable. The experiment by McLaughlin and Bishop (1969) showed that the regrowth of a sward after an early cut of hay (October) produced larger weight gains in weaners than the regrowth after a later cut hay (November) and it was interpreted that the herbage quality was the major factor. Birrell (1978) has shown that the organic matter digestibility (DOM) of abundant herbage can fall from 75% at the end of October to below 60% within a period of 5 weeks and stay at this level until the following autumn. However, when the herbage on offer was maintained at low levels (*c.* 2.0 t DM/ha) the DOM throughout the summer period rarely fell below 65%. There is scope for a management strategy using older stock which will enable herbage yields to be kept low for the benefit of young animals which require the highest quality diet possible.

Late summer-early autumn

McLaughlin (1973) suggested that the variation between years in response to different feeding treatments he observed for weaners grazing summer pastures may have been due to variation in the digestible energy and protein content of the pasture. The period December to April inclusive is considered the period of greatest concern, for although the quantity of pasture present is high the feeding value and, in particular, the amount of it animals will eat, are low. Some form of managing the herbage yield which keeps quality high could be beneficial for the management of young animals, although the most useful solution would appear to be the establishment of better species, e.g. lucerne.

In Victoria lucerne is often used in conjunction with spring lambing, but some graziers who have tried spring lambing without lucerne have reverted to earlier lambing. The advantage of lucerne for weaner sheep in summer and autumn is clear from comparisons made with grass pastures near Canberra (Morley and Axelsen 1965). As digestibility falls there is a smaller reduction in intake with legumes than with grasses (Demarquilly and Jarrige 1973). In addition the rate of fall in digestibility is lower with legumes than grasses. For per head performance by weaner sheep, lucerne compares well with the annual fodder crops, Sudax and Japanese millet (Dann 1972) and rape and turnips (Faulkner and Lear 1975). Even given adequate irrigation, perennial ryegrass remains inferior for weaner sheep relative to irrigated lucerne or white clover (Wilson 1966). Current levels of productivity from pasture based on perennial ryegrass and subterranean clover vary from 4 to 11 t DM/ha/yr (Cayley *et al.* 1980) or 50 to 100 kg of clean wool (Birrell 1978). Methods of increasing the productivity of pastures, and improving nutrition of grazing animals are discussed in the following papers.

SEASONAL VARIATION IN THE NUTRITIVE VALUE OF SOME PASTURE SPECIES IN WESTERN VICTORIA AND SOME EFFECTS ON THE GROWTH OF WEANER SHEEP

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EXPERIMENT 1

In July 1976, the seasonal variation in the nutritive value of five of the most commonly sown species in the Western District, *viz* perennial ryegrass *(Lolium perenne)*, phalaris *(Phalaris aquatica)*, Yorkshire fog grass *(Holcus lanatus)*, subterranean clover *(Trifolium subterraneum)* and capeweed *(drctotheca calendula)* was examined. The pasture was grazed and samples of herbage cut at ground level, were taken at fortnightly intervals until January. These samples were analysed for *in vitro* dry matter digestibility (DMD), crude protein (CP), crude fibre (CF), soluble carbohydrate (WSC), neutral detergent fibre (NDF) and, because of its inverse correlation with voluntary intake, the energy consumption in milling herbage to pass through a 1 mm screen (Chenost 1966; Jones *et al.* 1974).

Levels of WSC were relatively low throughout the winter (4-6%) rising sharply to a peak (10-13%) in spring then declining as the plants matured and senesced. Subterranean clover (Sub) had lower levels than the other species although it ranked second only to ryegrass by late spring. Sub also had a significantly lower CF and higher WSC:NDF ratio than the grasses throughout the year. The three grasses exhibited a remarkable similarity in terms of CF, CP and DMD.

During autumn and winter, DMD remained relatively constant in all species. Sub had a significantly lower DMD (74%) than capeweed, ryegrass and phalaris (79-80%) until late spring. At flower initiation, the DMD of the grasses declined rapidly. In contrast, the DMD of Sub remained steady after flowering and did not decline until 4-6 weeks after the grasses. The decline in the DMD of Sub occurred after it began to bury its burr in mid December. Its DMD in mid February was less than *50%.* During the summer period DMD remained below 65% for all species. It is likely that sheep will either maintain or lose weight in such circumstances (Birrell 1978).

In early January the CP of the grasses was less than 7% and must be regarded as being at a critical level for optimal microbial activity (Blaxter and Wilson 1963; Milford and Minson 1966). By contrast it was observed that Sub

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had a CP value in excess of 10% in mid February.

The energy consumption in milling for the grasses rose from 40 J/g DM in October to 200 J/g DM in mid December. Sub attained a value of 80 J/g DM by mid December but it took until mid February for energy consumption to reach 170 J/ g DM.

It was concluded that Sub had some potential for improving animal production during late spring and summer despite its apparent low digestibility in mid February. Another experiment to examine the effect of increasing the proportion of Sub in the diet of Merino weaners (August/September born) was carried out during the summer of 1977/78.

EXPERIMENT 2

The experiment compared the five treatments presented in Table 1. A control treatment, T1, consisted of mature perennial ryegrass, fog grass pasture. In T2 and T3 the hays were fed *ad libitum* and each hay was consumed at about 800 g/day. The hays were made outside the treatment areas. The Sub dominant pasture, T4, was obtained by spraying the pasture in the previous winter with carbetamide to increase the proportion of Sub. The strawberry clover pasture, T5, was growing on a reclaimed peat swamp. The experiment lasted from 15 December 1977 to 19 April 1978 except for T4 which was terminated on 22 March due to insufficient pasture. Initial group live weight was 21.0 ± 0.4 kg (mean ±SE). A stocking rate of 14 sheep/ha was used for all treatments. Sheep were shorn before treatment and after the end of the experiment all sheep were dyebanded and then grazed together.

The chemical and physical properties of Sub found in Experiment 1 were generally comparable in this experiment. The CP of the Sub remained fairly constant (15%), the proportion of NDF increased from 36 to 61%, the energy consumption in milling increased from 50 to 164 J/ g DM and WSC decreased from 8.1 to 1.3% of DM. Results in Table 1 demonstrate the poor production of weaners on mature pasture and the potential improvement that can be obtained by the use of a perennial legume.

TABLE 1 Effect of treatment on liveweight gain and wool production .

Treatment	Clover content Nov '77 (%DM)	Liveweight gain (g/d) Days 0-125	Liveweight gain (kg) Days 125-360	Greasy wool production (kg) Days 0-125	Greasy wool production (kg) Days 125-360	Total 360
1.Mature pasture	20	-6.6^{d}	26.3^{a}	1.12^{c}	2.92^{a}	4.04^{c}
2.Mature pasture	20					
& Sub hay (20% CP)	80	35.1^{bc}	18.9^{b}	1.57^{b}	2.93^{a}	4.50^{ab}
3.Mature pasture						
& hay (14% CP)	20	43.7^{b}	19.1^{b}	1.39^{bc}	2.90^{a}	4.29^{bc}
4.Sub dominant pasture	80	30.3^{c}	20.2^{b}	1.32^{bc}	2.87^{a}	4.19^{bc}
5.Strawberry clover	60	92.8^{a}	13.1^{c}	1.93^{a}	2.93^{a}	4.86^{a}

Means with different superscripts are significantly different ($P<0.05$) according to Duncan's multiple range test.

Weaners grazed on strawberry clover, T5, had higher greasy fleece weights ($P<0.05$) at the first shearing after treatment (day 360) than the control weaners, T1 (20.3% or 0.82 kg). However, no difference in wool production was observed between groups from the end of treatment until first shearing nor at the second shearing after treatment. The results indicate that although weaners were able to compensate to a marked degree in winter and spring in terms of liveweight gain (Table 1) their greasy fleece weight was greatly affected by nutrition in their first summer.

Conserving Sub as hay in spring and feeding it as a supplement to weaners grazing mature pasture was clearly advantageous to wool production compared with allowing it to mature and dry *in situ.* However wool production was still less than that obtained from weaners grazing strawberry clover.

THE EFFECT OF SUPERPHOSPHATE HISTORY ON WOOL PRODUCTION FROM PASTURE ON A BASALT-DERIVED SOIL

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At Penshurst, on the basalt plains, Merino wethers were continuously grazed at 20 and 12.5/ha in a trial that commenced in 1966. Previously the subterranean clover, perennial ryegrass pasture had received a total of 2.6 t superphosphate/ha. By 1977, three superphosphate histories had been developed; (A) superphosphate at 125 kg/ha/yr, (B) superphosphate of 125 kg/ha/yr until 1973 and (C) no superphosphate since 1966. In 1977, the wool growth (dyebanded staples), pasture growth, and the yield of pasture present were measured over autumn, winter and spring. At 20 sheep/ha the three history treatments were replicated and results from these plots are given in Table 2. Phosphate sorption value for this soil was 133 ppm and buffering capacity was 20 ppm P sorbed/0.1 g P/ml of equilibrium solution (0.3 ppm P in solution) (Ozanne and Shaw 1968).

TABLE 2 Wool production, pasture growth, modified Olsen available soil phosphorus (P) test, and optimum fertilizer P requirement

Superphosphate history (kg/ha)	Clean fleece wt. (kg/hd)	Fleece value ($/hd)	Pasture growth (t DM/ha)	Clover in spring pasture (% DM)	Soil P (0-10 cm) ppm	Opt. P† (kg P/ha/yr)
A	3.4	11.10	7.59	10	14.2	7
B	3.1	10.10	6.27	12	10.1	14
C	2.6	9.00	5.34	16	6.2	23

† Optimum fertilizer P as calculated from small plot experiments (Kelly 1979).

Comparing history C with history A, the withholding of superphosphate for 11 years reduced pasture growth by 48, 36 and 24% in autumn, winter and spring, respectively. The associated reduction in wool growth on these pastures was 40, 48 and 20%, respectively. The proportional wool penalty was less in autumn than winter, although the pasture deficit was greatest in autumn. This anomaly is considered to be due to the influence of the carryover of spring/summer growth from 1976, into the autumn of 1977. Seasonal pasture allowance, which was calculated by adding current pasture growth to the yield of pasture present at the beginning of each season, and dividing by the mean live weight during the season, showed a curvilinear relationship with wool growth (Fig. 1). Within the observed range of pasture allowance, the relationship was asymptotic; the correlation coefficient was 0.86.

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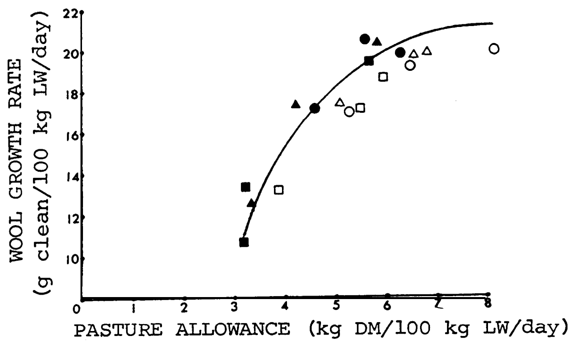

Fig. 1 The effect of pasture allowance (χ) on wool growth rate (Y)
$Y = 20.2 - 91.5 \exp(-0.76\chi)$.
History: A = O; B = Δ; C = □. Solid symbol 20 wethers/ha; open 12.5/ha.

Samples collected on 27 October 1977 showed that the various P histories were reflected in the concentration of P in sub. clover with values of 0.30, 0.25 and 0.22% P for histories A, B and C respectively. Such variation apparently had no direct effect on wool growth rate (Fig. 1) and the effect of P history on wool growth was considered to be due simply to its effect on the quantity of pasture grown.

Small-plot experiments showed that pasture production on C plots could equal that obtained on A plots if the fertilizer application was 30 kg P/ha. The co-operation of Mr. R.B. Ritchie, "Blackwood", 'Penshurst, with Department of Agriculture staff at Hamilton is gratefully acknowledged.

THE POTENTIAL OF PASTURE LEGUMES FOR IMPROVING THE QUALITY OF SUMMER-AUTUMN FEED

K.F.M. REED*, P.T. KENNY* and P.C. FLINN*

Reviews of ruminant performance on different pastures (Reed 1972a, 1976) emphasise the importance of the voluntary intake value of herbage when the yield of pasture present is high - as during the hot, dry summer months at Hamilton. During these months considerable differences have been recorded in south eastern Australia, between the performance of sheep on perennial grass-sub clover pasture, and perennial legume pasture such as lucerne (Reed *et 'al.* 1972)' or white clover (Reed 1972b). However, many districts contain only small areas of lucerne. It is claimed that lucerne does not persist as most soils are too wet during winter. New disease-resistant cultivars may alleviate this problem. The use of white clover has been limited due to its poor drought tolerance. Newer cultivars of Mediterranean origin (e.g. Haifa) have improved drought tolerance and increased autumn-winter yields (Reed 1979b).

We are examining a range of legume species and cultivars hoping to identify species for each of several soil types and climates, which may be able to persist and provide quality feed in summer. Initial results from a restricted group of species sown at Hamilton in 1978 on Normanby silty loam show that when spring

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growth was left standing over the summer-autumn months, tall fescue and various legumes had a lower energy consumption in milling than did perennial ryegrass and *Phalaris aquatica* (Table 3). The decline in DM digestibility and protein concentration of spring growth during summer-early autumn is also less for legumes than for grasses (Table 4).

TABLE 3 Dry matter (DM) production over summer-autumn 1978/79 and range of energy consumption in milling late spring regrowth sampled monthly from December to April

Species and cultivar	DM production†‡ (t/ha)	Energy consumption (J/g DM)	
		min.	max.
White clover, Haifa	3.13 a	59	116
Giant shaftal clover	2.58 ab	55	131
Strawberry clover, Salina	2.42 abc	36	97
Tall fescue, Demeter	2.35 abcd	47	125
White clover, Grasslands (G) Huia	2.05 abcd	38	69
Perennial ryegrass, Victorian	1.82 abcd	104	254
Lucerne, CUF 101	1.81 abcd	43	123
Lucerne, WL 318	1.71 abcde	33	135
Phalaris aquatica, Australian	1.64 abcde	92	232
Red clover, G. Turoa	1.61 abcde	56	85
Alsike clover	1.54 abcde	67	115
Red clover, G. Pawera	1.30 abcdef	43	111
Red clover, G. Hamua	1.24 bcdef	58	128
Red clover, Krano	1.21 bcdef	41	90
Lucerne, Falkiner	1.00 cdef	51	126
Red clover, Olvi	0.97 def	68	115
Greater lotus, G. Maku	0.75 ef	99	203
Birdsfoot trefoil, WS 3012	0.62 f	54	144

† In Tables 3, 4 and 5, figures followed by the same letter are not different ($P>0.05$) by Duncan's multiple range test.

‡ Total for two harvests. Figures are retransformed means; analysis of variance was carried out on log-transformed data.

Animal production systems may be improved by including special purpose summer pastures based on appropriate perennial species. Small areas of lucerne (on gravelly crests, parna dunes and volcanic ash soils), and strawberry clover (on low lying peaty flats) are established in parts of the Western District and provide valuable summer grazing. Where appropriate soil types are unavailable, short-term special purpose pastures such as red clover could be similarly developed. The dried-off growth from the annual, giant shaftal clover, may also be of value. Both these species are also suitable for providing hay or silage. When wilted, the feeding value of red clover silage is considerably greater than wilted grass silage of similar digestibility (Reed 1979a). Late cut red clover hay may provide a supplement with a remarkably high feeding value (Mosely 1974).

The performance of August-September born Corriedale lambs, when weaned on to different pastures is being measured. A range of species for each of several soil types has been established. Initial results for the experiment on silty loam illustrate the potential of perennial legumes relative to the more summer active of the perennial grasses available, and relative to a nutritious feedlot ration (Table 5).

TABLE 4 *In vitro* digestibility and Kjeldahl N of standing feed, December to April (regrowth following a mid October harvest in 1978)

Species and cultivar	DMD%			N (% DM)		
	Dec 7	Feb 7	Apr 3	Dec 7	Feb 7	Apr 3
White clover, Haifa	82.6b	53.9bc	43.4ab	3.57ab	2.11bc	2.29b
White clover, G. Huia	-		-	3.84a	2.54a	2.64a
Strawberry clover, Salina	84.7b	63.8a	53.0a	3.27bcd	2.11bc	2.19bc
Giant shaftal clover	91.2a	60.7ab	45.5ab	3.40bc	1.95bc	1.85cde
Red clover, G. Hamua	74.7c	51.5bc	39.7b	3.20bcd	1.79cd	1.51fgh
Red clover, Krano	-		-	3.33bc	1.93bc	1.93cde
Alsike clover	-		-	3.02cd	1.94bc	1.72defg
Lucerne, CUF 101	65.3d	60.5ab	50.7a	2.27e	2.30ab	1.91cde
Birdsfoot trefoil, WS3012			-	2.12e	1.81cd	1.59efgh
Greater Lotus, G. Maku	50.2f	39.2d	29.6c	2.87d	1.56d	1.44ghi
Tall fescue, Demeter	63.5de	55.3bc	52.4a	1.40f	0.93e	1.21i
Phalaris aquatica, Aust.	53.9f	41.0d	36.5bc	1.25f	0.89e	0.76j
Perennial ryegrass, Vic.	60.6e	38.4d	41.0b	1.04f	0.83e	1.30hi

TABLE 5 Weight gain by weaner lambs in a feedlot, or grazing late spring regrowth during summer (initial live weight 26 kg, stocked at 14/ha)

Pasture species and cultivar†	LW gain (kg) Jan 7 - Mar 4 1980
Red clover, G. Hamua	9.89 a
Giant shaftal clover (Trifolium resupinatum)	8.58 a
Lucerne, WL318	7.07 b
Strawberry clover	6.81 b
White clover, Haifa	6.53 b
Cocksfoot, Porto + Sub. clover, Mt Barker	3.82 d
Phalaris hybrid, Siro 1146‡ + Sub., Mt Barker	3.61 d
Tall fescue, Demeter + Sub., Mt Barker	3.25 d
Perennial ryegrass, Victorian + Sub., Mt Barker	2.82 d
In feedlot:	
Strawberry clover hay, *ad libitum* + lupins (0.3 kg/day)	5.16 c

† Sown on Normanby silty loam in April 1979 except lucerne (sown September) and strawberry clover (an established sward growing on a reclaimed peat swamp).
‡ Poorly established, predominantly barley grass and soft brome grass.

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GRAIN AND PROTEIN SUPPLEMENTS FOR GRAZING SHEEP AND CATTLE

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CURRENT PRACTICE AND ALTERNATIVES

. A traditional approach to alleviating seasonal limitations to nutrition of grazing cattle and sheep is the provision of supplementary feed to animals at pasture. Stock most vulnerable to undernutrition have priority; in summer, for example, these will include late spring-born lambs, early-weaned calves and

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autumn-lambing ewes. Apart from hay, which will not be considered here, the most common form of supplementation is oaten grain, which is both cheap and readily available. Other supplements which may be used for grazing animals include other cereal grains, lupin grain, commercial sheep nuts and various protein supplements (e.g. soya bean, groundnut and linseed meals, meat meal, fish meal). These are not generally considered by the producer as alternatives to oats because of the additional expense involved. Nevertheless there are times when the extra benefits conferred by some of these supplements may make their use worthwhile.

The overall effect of supplementation on the individual animal varies with the quality of the supplement and the amount eaten, with the quality, quantity, height and dry/green ratio of the pasture, and with the physiological state and subsequent compensatory intake and growth of the animal.

The two grazing situations where supplementation is primarily used are, first, when the herbage is high in cell wall constituents but low in protein and soluble carbohydrates, and, second, when the pasture is green and readily fermentable, but low in availability, as it is in winter.

SUPPLEMENTATION ON MATURE SUMMER/AUTUMN PASTURES

On rare occasions late-summer and autumn pastures may be too low in protein content to supply sufficient nitrogen for rumen micro-organisms to function efficiently. In such cases there may be a response to non-protein nitrogen (NPN), as long as some other factor is not restricting rumen function (e.g. available energy, sulphur). Further improvement in intake, and consequently in liveweight gain, may be achieved if more feed protein reaches the intestines without being broken down in the rumen (Egan 1965; Egan and Moir 1965). Kempton and Leng (1979) have quantified this effect with four-month-old lambs; the effect on liveweight gain of supplementation with NPN and rumen-degradable protein, and the increased effect of addition of protein not degradable in the rumen, appeared to be solely due to the influence on intake.

Similar effects have been obtained at the Pastoral Research Institute with four-month-old Merino weaners fed individually on mature herbage (5.8% CP) harvested in March from dry pasture and supplemented with soya-bean meal, which contains a proportion of protein undegradable in the rumen (Table 6).

TABLE 6 Herbage intake and daily weight gain of weaners on different levels of soya bean supplementation (eight weaners/group)
(Foot, McIntyre and Heazlewood unpublished)

	g/day	g/day	g/day	g/day
Soya-bean meal on offer	80	120	160	200
Herbage dry matter intake:				
With no supplement	386	398	382	392
With supplement (SD)	510(74.4)	562(84.2)	572(70.7)	555(57.0)
Mean change in fasted live wt.	+17(11.4)	+44(13.1)	+45(14.7)	+67(15.4)

The mean change in fasted live weight during this experiment was about -50 g/day for unsupplemented weaners. Similar weaners losing weight while grazing summer pasture (8.6% CP) gained 40 g/day with a supplement of 156 g oats and twice that gain was achieved with soya-bean meal given to supply the same amount of metabolisable energy as oats. With the protein supplement further responses in weight gain could be achieved when additional energy (molasses meal) was given.

Weaned cattle appear to respond more to energy and less to protein supplementation than do weaned sheep. Good responses to oat supplementation have been obtained in early-weaned calves grazing hay aftermath (Morgan,. and Saul 1976; Morgan and Behrens 1978). Supplementation with linseed meal alone produced a small response which may have been due to its energy content. Biuret supplementation of steers grazed on aftermath (Morgan and Behrens 1978) or on dry summer pasture, oat stubble or standing oaten hay (Smith 1974) produced small and statistically non-significant liveweight responses.

Effects of undegraded dietary protein reaching the post-ruminal digestive tract are likely to be greatest where protein requirements are high (Ørskov 1978), in young growing sheep and cattle and in lactating animals.

SUPPLEMENTATION ON WINTER PASTURE

Unless herbage availability is very low, feeding of cereal grains or lupin grain to sheep at pasture is more likely to result in substitution than in supplementation (Egan and Learmonth 1978). A typical result is given in Table 7.

TABLE 7 Intakes and liveweight gains of Corriedale wether hoggets supplemented on winter pasture (McIntyre, unpublished)

	g dry matter/day		
	Pasture only	+360 g oats	+270 g oats/85g soya bean
Mean total intake (g digestible DM)	744	768	902
Mean liveweight gain (g/day)	112	113	160

Substitution was incomplete when soya-bean meal was included and the increased liveweight gain reflected the greater overall intake in this group.

Substitution of pasture for oats seems to occur less in cattle, possibly because of their inability to graze short winter pasture as effectively as sheep. Steers grazed at 2.5/ha with herbage availabilities around 1000 kg/ha responded well to oat supplementation (Morgan and Ronan 1977).

DECISIONS ON WHEN TO SUPPLEMENT

A clear decision on the use of supplementary feeding can be made when deaths are likely to occur without it, for instance, in small late spring-born lambs which are'unable to cope with dry summer pasture, and in autumn-lambing ewes where pregnancy toxaemia is a risk in late pregnancy. Strategic supplementation to finish animals for out-of-season markets may also be worthwhile on winter pasture.

Apart from these examples managerial decisions on supplementation at pasture can be very difficult because of the complex interactions involved. There are three important sources of uncertainty. These are: first, the extent to which the animals can select a better quality diet from the pasture (cattle and sheep differ); second, thevariation in intake of the supplement between individual animals, often especially noticeable in sheep on cereal grains; and third, the extent to which compensatory intake and growth may nullify the effects on animal production of a temporary inadequacy in nutritive intake from pasture.

CONCLUSIONS

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These papers have discussed the limitations to growth and effective use of pastures in an area where animal production is overwhelmingly dependent on the grazing ruminant.

During the late autumn-winter period autumn-lambing ewes and cows which will be lactating when pasture growth is slow are frequently unable to obtain sufficient pasture to meet these nutritional requirements. This may restrict milk output and reduce the ability of cows to conceive in a short period resulting in longer calving intervals. In addition, given the higher intake of lactating animals, effective grazing pressure may be increased at a time when pastures can least tolerate it. Some'of the possibilities for modifying this situation, such as the continued use of superphosphate and the use of supplements to try to reduce grazing pressure have been discussed.

In late summer-early autumn the problem again is the failure of the animal to eat enough, but in this case it is not due to lack of available pasture but to the inability of the animal to cope with the poor quality roughage. It was shown that legume pastures can alleviate undernutrition of vulnerable stock at this time. Special legume pastures may also allow production of high quality hay for winter use.

Manipulation of the animal's productive cycle may improve the pattern of pasture use (e.g. changing lambing or calving times), and buying-in of stock can allow more effective use of spring pasture. Management systems including fodder conservation, deferred grazing and allocation of feed resources according to requirement in mixed cattle/sheep enterprises may also have a place. More information is required for all these practices before economic assessment can be made of their use in different situations.

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