THE UTILIZATION OF PERENNIAL RYEGRASS AND WHITE CLOVER BY YOUNG SHEEP

P. V. RATTRAY AND J. P. JOYCE
Ruakura Agricultural Research Centre, Hamilton

SUMMARY

Perennial ryegrass and white clover grown during spring 1967 were harvested and frozen at similar digestibilities over a series of cuts. These cuts were later fed as pure or 50/50 mixed diets on an *ad libitum* or restricted basis to Romney wether hoggets in a 94-day feeding trial from April to July, 1968.

White clover had higher crude protein levels, but a lower carbohydrate content than perennial ryegrass. The DM digestibilities of the perennial ryegrass, white clover and 50/50 diets were 73.1, 75.3 and 73.7%, respectively. There were no significant differences in the *ad libitum* intakes of DM, OM, N or gross energy of each ration.

Empty liveweight gain, efficiency of empty liveweight gain and wool growth were greatest for sheep fed a white clover diet compared with perennial ryegrass. There was no difference in energy and nitrogen retention per kg OM intake between the three diets at maintenance levels of feeding. At levels of feeding above maintenance, significantly more energy and nitrogen were retained per unit feed intake for the white clover diet than for the ryegrass diet.

The results obtained in this trial with spring-grown herbages are discussed in relation to a previous trial using autumn herbages.

GRAZING TRIALS have demonstrated that white clover (*Trifolium repens* L.) dominant pastures support higher growth rates of young sheep than do pastures dominant in perennial ryegrass (*Lolium perenne*) (Sinclair *et al.*, 1956; Rae *et al.*, 1963; McLean *et al.*, 1965; Hight and Sinclair, 1965).

Joyce and Newth (1967) compared these two pasture species using young sheep housed indoors and fed fresh autumn-grown herbages of similar digestibility. The superior performance of the white-clover-fed animals was attributed to higher voluntary intakes and to more efficient utilization of the digested nutrients. Although a large difference in nutritional value between the two species was demonstrated, the growth rates obtained (even for the white-clover-fed animals) were relatively low compared to those reported in field trials (Hight and Sinclair, 1965; McLean *et al.*, 1965). This may have been due to the quality of the autumn-grown herbage, but factors associated with pen feeding may also have been important.

In the present experiment the comparative slaughter technique was used in order to:

(1) Compare the nutritive value of spring-grown perennial ryegrass (PRG) and white clover (WC).

(2) Examine their feeding value when fed as a mixed diet.

(3) Provide data enabling a comparison to be made between herbage grown in autumn and spring.

EXPERIMENTAL

ANIMALS

On April 3, 1968, forty-two Romney wethers of approximately seven months of age were randomized into one group of 12 animals and six groups of 5 animals on the basis of their 24-hour fasted liveweights (range 16.3 to 23.1 kg, mean 20.2 kg). All animals were drenched with thiabendazole at the commencement of the trial and weighed at 5-day intervals. Total faecal and urine output was measured for each sheep.

DESIGN

Other than the initial slaughter group of 12 animals which was slaughtered on Day 0 of the experiment, the groups were fed either one of the pure species or a mixed diet as shown in Table 1. The trial was of 94 days' duration.

FEEDING

All animals were housed indoors in metabolism crates and individually fed daily at 09.00 hr on frozen herbage

TABLE 1: DESIGN OF TRIAL

No. of Sheep	*Group Description*	*Composition of Diet % WC*	*% PRG*	*Feeding Level*
12	Initial slaughter*	—	—	—
5	LWC†	100	0	500 g DM/day
5	HWC†	100	0	*ad libitum*
5	L50/50†	50	50	500 g DM/day
5	H50/50†	50	50	*ad libitum*
5	LPRG†	0	100	500 g DM/day
5	HPRG†	0	100	*ad libitum*

*Sheep slaughtered on Day 0.

†Sheep slaughtered on Day 94.

which had thawed overnight at room temperature. The restricted groups were offered 500 g dry matter (DM) daily (as assessed from DM % at freezing), and the *ad libitum* groups were fed at a refusal level of at least 20%. For sheep being fed the mixed diet, each species was placed in a separate compartment of the feed box to facilitate the estimation of the amount of each species refused.

FEEDS

Harvesting and freezing: During spring 1967, several cuts of each species were taken with a flail harvester from the pure pasture species plots described by Joyce and Newth (1967), frozen and stored at -18° C until required for feeding. Samples of each pasture were taken immediately prior to harvesting and at freezing for botanical analysis and DM estimation, respectively. Details of the cuts taken are shown in Table 2.

TABLE 2: HARVESTING DETAILS AND PASTURE PURITY

	Perennial Ryegrass (PRG)*			*White Clover† (WC)*	
Dates harvested (1967)	Oct. 9, 10, 11	Nov. 29	Dec. 18	Nov. 8, 14	Dec. 5, 6, 7, 12
% of total DM harvested	49.1	33.2	17.7	22.9	77.1
% Purity (on DM basis)	96.5	97.3	97.0	88.6	92.3

*Extraneous species in PRG pasture: Plantain *(Plantago lanceolata)*, dandelion *(Taraxacum officinale)*, buttercup *(Ranunculus sceleratus)*, white clover *(Trifolium repens* L.).

†Extraneous species in WC pasture; Docks *(Rumex obtusifolius* L.), paspalum *(Paspalum dilatatum)*, plantain, dandelion, perennial ryegrass *(Lolium perenne* L.).

Fertilizer: Two weeks prior to the first harvesting the area received a basic dressing of 5 cwt lime and 1 cwt of 30% potassic superphosphate per acre. To simulate the return of nutrients that would occur under grazing, a fertilizer mixture as recommended by McNeur (1953) was applied after each cut was harvested.

SLAUGHTERING

The slaughtering, sampling and analytical procedures were similar to those used by Joyce and Newth (1967) except that in the present trial the skin was included with the offal fraction.

TABLE 3: CHEMICAL COMPOSITION OF WC AND PRG
(All results on DM basis)

	WC	*PRG*
Crude protein (%)	25.89	20.47
Water soluble sugars (%)	7.94	12.62
Hemicellulose (%)	9.70	12.63
Cellulose (%)	20.93	25.43
Lignin (%)	8.23	6.82
Ash (%)	10.32	12.72
DM (kcal/g)	4.380	4.281
Acid detergent fibre (%)	25.75	28.08

RESULTS

CHEMICAL COMPOSITION OF FEEDS

Table 3 shows data for chemical analyses from the two feeds. While the calorific values of both feeds were very similar, the PRG had 20 to 30% higher structural carbohydrate levels, nearly 60% higher soluble carbohydrate levels than WC, and 12% and 20% lower lignin and crude protein contents, respectively.

DIGESTIBILITY AND INTAKE OF FEEDS

The digestibility of the DM, OM, N and gross energy (GE) of the various rations are shown in Table 4. The digestibilities of both species were similar, although the WC was more digestible than the PRG, but these differences were not statistically significant. Except in the case of GE, the digestibility of the mixed ration was intermediate. The ratios of PRG to WC dry matter actually consumed by the groups fed *ad libitum* and restricted 50/50 were 46.3 : 53.7 and 51.0 : 49.0, respectively.

TABLE 4: INTAKE AND DIGESTIBILITY OF RATIONS

Rations Fed	*HWC*	*H50/50*	*HPRG*	*LWC*	*L50/50*	*LPRG*
DM intake (g/day)	773.5	746.9	710.9	469.1	472.7	450.0
OM intake (g/day)	694.7	666.7	628.0	420.9	418.9	394.5
N intake (g/day)	31.4	27.5	22.8	19.4	17.4	14.5
GE intake (kcal/day)	3,330	3,198	3,068	2,045	2,031	1,915
DM digestibility (%)	74.6	73.7	73.2	75.9	73.6	73.0
OM digestibility (%)	77.7	77.3	77.0	79.7	77.5	77.3
N digestibility (%)	73.7	73.4	71.8	76.2	73.7	72.1
GE digestibility (%)	73.2	72.3	73.1	75.1	73.0	73.0

The groups fed *ad libitum* ate approximately 60% more DM, OM, N and GE than their respective restricted groups (Table 4). For these *ad libitum* groups, intakes of DM, OM, N and GE were not significantly different.

Weight Changes

There was a marked effect of feeding level on empty body weight gain (body weight less intestinal tract content) carcass weight gain (Table 5) and the efficiency of these weight gains expressed per 100 kg DOM intake ($P <$ 0.001).

Table 5: Weight Changes and Wool Growth

Rations Fed	*HWC*	*H50/50*	*HPRG*	*LWC*	*L50/50*	*LPRG*
Initial LW (kg)	20.41	20.41	19.60	19.50	20.87	20.59
Empty bodyweight gain (g/day)	122.8	97.3	85.5	41.5	33.0	27.2
kg Empty body WG/100 kg DOM I	22.8	18.9	17.7	12.4	10.2	8.9
Carcass weight gain (CWG) (g/day)	59.6	48.7	39.7	16.0	13.4	12.3
kg CWG/100 kg DOM I	106.5	92.5	78.3	47.6	42.1	39.5
Wool growth (g/day)	13.3	13.2	9.6	7.8	4.6	3.6
kg Wool growth/ 100 kg DOM I	2.46	2.57	1.99	2.33	1.42	1.18

While the general ranking of averages for the effect of feed type on empty body and carcass weight gains and their conversion efficiencies was WC > 50/50 > PRG significant differences could be demonstrated only between WC and PRG for empty body weight gain (EBWG) and EBWG/100 kg DOMI ($P < 0.05$ and 0.01, respectively). No significant differences were found for carcass weight gain and efficiency of carcass weight gain. The EBWG of the sheep on the mixed diet did not differ significantly from the average EBWG of the sheep on the two pure diets.

Wool Growth

There were significant differences between diets in wool growth (Table 5) and in the efficiency of wool growth ($P < 0.05$). The *ad libitum* groups grew more wool in each case than did the restricted groups ($P < 0.001$) but most notable was the inferior wool growth rate of PRG groups and the high wool production of the restricted WC group.

Teat Weights

All teats were collected and weighed at slaughter as a method of assaying for differences in plant oestrogen content. The average wet teat weights were 0.55 g, 0.50 g, 0.48 g for the WC, 50/50 and PRG groups, respectively. These differences were not statistically significant.

Table 6: Energy Balance Data
(kcal/day)

Rations Fed	*HWC*	*H50/50*	*HPRG*	*LWC*	*L50/50*	*LPRG*
Intake	3,330	3,198	3,068	2,045	2,031	1,915
Digested	2,437	2,311	2,244	1,536	1,483	1,398
Faeces	893	887	824	509	548	517
Urine	181	172	157	122	120	110
Methane	246	238	228	170	167	157
Heat production	1,621	1,520	1,597	1,167	1,129	1,090
Retention	389	381	262	77	67	41

Energy Retention

The energy balance data are summarized in Table 6. Heat production represented the greatest source of apparent energy wastage (47 to 57%). This form of energy loss represented a greater percentage of ingested energy for the sheep on restricted diets compared with those on *ad libitum* feeding (56.5 *cf* 49.4%). Faecal energy loss accounted for 25 to 28% of the gross energy consumed, while urinary and estimated methane losses (Blaxter and Clapperton, 1965) were 5 to 6% and 7 to 8%, respectively.

The three groups of sheep on restricted diets were just above energy equilibrium with 2 to 4% of ingested energy being retained although there was one animal in each of the LWC and L50/50 groups and two in the LPRG group that were apparently in negative energy balance despite all sheep exhibiting empty body gains. With *ad libitum* feeding considerably more energy was retained (8.6 to 11.9%) than at restricted levels ($P < 0.01$). No significant differences in the levels of energy retention were found between feed types at either the restricted or *ad libitum* feeding levels.

Energy Retention and Food Inake

The regressions relating energy retention to organic matter (OM) intake (Fig. 1) were:

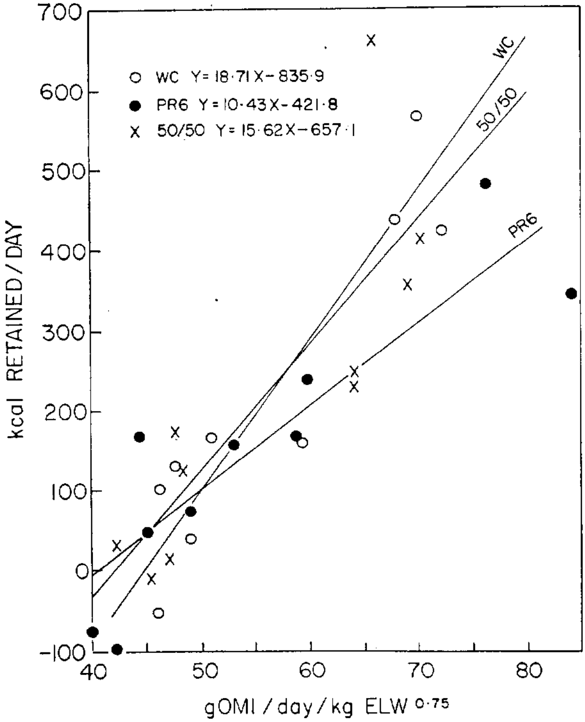

FIG. 1: *The effect of level of OM intake on the amount of energy retained.*

WC;	Y	$= 18.71 \times - 835.9$
PRG;	Y	$= 10.43 \times - 421.8$
50/50;	Y	$= 15.62 \times - 657.1$
where	Y	= kcals energy retained/day
	X	= g OMI/day/kg ELW $^{0.75}$
	ELW	= mean empty liveweight in kg.

The regression coefficients were all highly significant (WC and PRG, $P < 0.001$; 50/50, $P < 0.01$) and those for WC and PRG were significantly different ($P < 0.01$).

The relationships for PRG and WC suggested that, while at *ad libitum* feeding levels there were appreciable differences in the amount of energy retained per unit of feed intake, these differences diminished as the feeding level approached maintenance. The mixed diet was not significantly different to the WC diet. Using these regressions, the calculated feeding level for zero energy balance for all

TABLE 7: NITROGEN BALANCE DATA
(g/day)

Rations Fed	*HWC*	*H50/50*	*HPRG*	*LWC*	*L50/50*	*LPRG*
Intake	31.4	27.5	22.8	19.4	17.4	14.5
Digested	23.1	20.1	16.4	14.7	12.8	10.4
Faeces	8.3	7.4	6.4	4.7	4.6	4.1
Urine	19.6	17.0	14.2	13.0	11.9	9.6
Retention	3.5	3.1	2.2	1.7	0.9	0.8

three diets was 42.7 g OMI/day/kg $ELW^{0.75}$ with 99% confidence limits of 33.9 and 49.4 (Tocher, 1952).

NITROGEN RETENTION

The nitrogen balance data are shown in Table 7. At the restricted plane of nutrition, the WC group retained a higher proportion of ingested N than the PRG and 50/50 groups. At the *ad libitum* level of nutrition, there appeared to be no difference between the WC and 50/50 groups; both retained more of the ingested N than the PRG group. The average retentions for the WC, 50/50 and PRG rations were significantly different ($P < 0.05$).

All sheep exhibited positive N balance; even those on restricted feeding levels that had exhibited negative energy balance.

The regressions relating N retention to OM intakes (Fig. 2) were:

WC; $Y = 0.105 \times - 3.37$
PRG; $Y = 0.069 \times - 2.26$
50/50; $Y = 0.112 \times - 4.26$
where Y = g N retained/day
X = g OMI/day/kg $ELW^{0.75}$

While each regression coefficient was highly significant ($P < 0.001$) there was no significant difference between the WC and 50/50 group regression coefficients but both differed significantly from the PRG regression coefficient ($P < 0.05$). It appears from these regressions that, while there was little difference between the three diets at levels approaching zero retention, at *ad libitum* feeding levels the amount of N retained per unit of OM intake was much lower for the PRG diet than for the WC and 50/50 diets. These relationships suggested that N equilibrium existed at an intake of 34.6 g OMI/day/kg $ELW^{0.75}$, with 99% confidence limits of 25.0 and 40.2 (Tocher, 1952). This intake is somewhat lower than that estimated to support energy equilibrium.

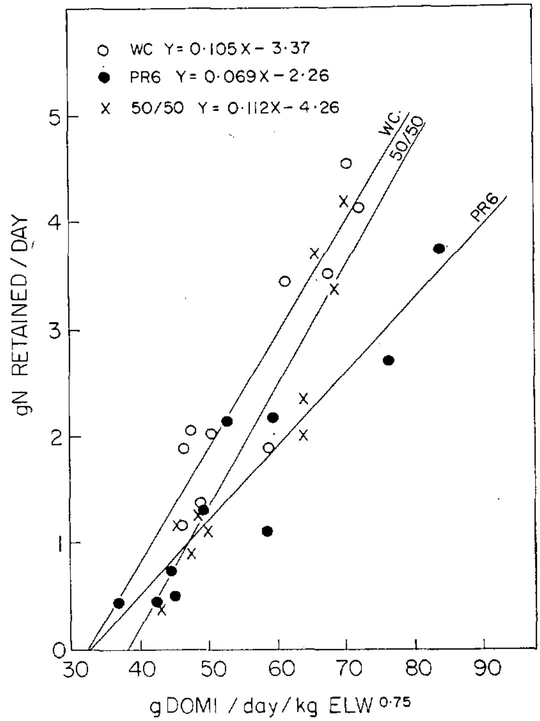

FIG. 2: *The effect of level of OM intake on the amount of nitrogen retained.*

DISCUSSION

INTAKE AND DIGESTIBILITY

The fact that there were no significant differences in terms of digestibility between the three diets is not unexpected since harvesting dates were adjusted in an attempt to minimize variations in digestibility between the PRG and WC swards.

Animal performance on any feed type will be a function of two inter-related factors — the level of food intake and the efficiency of utilization of the components in the diet. The significantly higher energy and nitrogen retention/unit OM intake of the WC group compared with the PRG group, especially at feeding levels well above maintenance, suggested that in this experiment the significantly higher ELW gain of the WC group is a reflection of a higher efficiency of utilization of digested nutrients. No evidence could be found to indicate that the animal response to feeding a mixed diet was other than that of a simple additive effect of the two rations (excluding possibly wool growth).

The significantly higher N retention of the WC and 50/50 diets could have been due to the slightly greater digestible N content of the WC, or that the WC contained plant oestrogens (Moule *et al.*, 1963) which promote N retention. The clover content of the 50/50 diet may have provided sufficient oestrogen to affect N retention. However, teat measurements of slaughtered animals did not support this theory.

While there were no significant differences between the three *ad libitum* groups in feed intake, the general trend was WC > 50/50 > PRG. The use of more animals per feeding group and a more refined trial design may have shown significant differences in intake.

Wool Growth

The greatest response to the type of diet fed was that of increased wool growth rates associated with feeding WC diets. Although McNaught and Chrisstoffels (1961) were unable to demonstrate any significant difference in the S content of grasses and clovers, the WC may have been higher in sulphur containing amino acids which are known to stimulate wool growth (Reis and Schinckel, 1963; 1964). It is also possible that the 25% higher crude protein content of the WC diet compared with PRG stimulated wool production.

Spring and Autumn Herbage

The voluntary intakes measured in this trial were lower than those obtained with fresh autumn herbage by Joyce and Newth (1967), by approximately 35% for WC and 13% for PRG. In the 1967 trial, WC-fed sheep consumed about 30% more OM, N and gross energy than PRG-fed sheep on *ad libitum* feeding. In the present trial the *ad libitum* WC group consumed only 10% more OM and gross energy but 40% more crude protein than the similar PRG group. The lower OM and GE intakes in this trial, especially for WC group, may have been a result of the frozen herbage being relatively unpalatable in comparison with fresh material. On a visual basis WC was noticeably more affected by freezing than PRG. However, in a trial at Ruakura (Hughes, unpubl.) comparing fresh and frozen pasture, it was found that there were no significant differences in the voluntary intake of mature wethers.

The weight gains and wool growth rates in this trial were greater than those reported in the 1967 trial, in spite of the lower feed intakes. Subsequently, the efficiency of these gains as expressed per 100 kg DOM I were greater than those achieved with the autumn harvested material. This was most notable in the case of the PRG. This difference could have been owing in part to the fact that the sheep used in this experiment were lighter in initial liveweight (20.4 kg *cf.* 26.5 kg) and consequently could have exhibited a greater growth response than did those in the earlier trial. The magnitude of the difference in weight gain between WC and PRG was less for spring-harvested than for autumn-harvested material.

While comparisons between experiments conducted in different years with different animals are dubious, the available evidence suggests that the spring herbage had a higher nutritive value than the autumn herbage; especially in the case of PRG. Comparison of the chemical analyses of the feeds used in this trial (Table 3) with those of the earlier trial (Table 8, Joyce and Newth, 1967) shows that, while both autumn species had higher crude protein levels, the greatest difference was shown in carbohydrate levels. The spring PRG herbage levels of hemicellulose and cellulose were 10% lower and soluble carbohydrates 317% higher than those of the autumn-harvested PRG, while the spring WC was 50% higher in soluble sugars and also 30% higher in structural carbohydrates than the autumn WC. These differences in chemical composition and their possible effects on rumen fermentation and rate of passage could be responsible for the smaller differences in the nutritive value of the two spring herbages, and the better overall performance from the two spring materials.

TABLE 8: CHEMICAL COMPOSITION OF WC AND PRG HARVESTED DURING PERIOD FEBRUARY 1-MAY 12, 1966

(Joyce and Newth, 1967)

	WC	*PRG*
Crude protein %	29.48	25.51
Water soluble sugars %	5.28	3.98
Hemicellulose %	7.03	14.07
Cellulose %	17.52	27.60
Lignin	6.49	5.93
Ash %	10.20	9.47
kcal/g DM	4.376	4.282
CP digestibility %	83.7	80.0

The main conclusions that could be drawn from these results were that WC was a superior feed compared with PRG for body and wool growth. At feeding levels above maintenance, the energy and nitrogen retention per unit feed intake was greatest for WC, while at maintenance levels of feeding differences tended to disappear. The addition of WC to a PRG diet appeared to be a simple additive effect for body growth, but not for wool growth.

The evidence suggests that the nutritive value of spring-grown herbage, especially PRG, is higher than that grown during the autumn period.

ACKNOWLEDGEMENTS

The assistance of the staff of the Nutrition, Chemical Servicing, Arts and Biometrics sections at Ruakura is gratefully acknowledged.

REFERENCES

Blaxter, K. L.; Clapperton, J. L., 1965: *Br. J. Nutr., 19*: 511.
Hight, G. K.; Sinclair, D. P., 1965: *N.Z. Jl agric. Res., 8*: 1079.
Joyce, J. P.; Newth, R. P., 1967: *Proc. N.Z. Soc. Anim. Prod., 27*: 166.
McLean, J. W.; Thomson, G. G.; Jagusch, K. T.; Lawson, B. M., 1965: *Proc. Ruakura Fmrs' Conf.*: p. 34.
McNaught, K. J.; Chrisstoffels, P. J. E., 1961: *N.Z. Jl agric. Res., 4*: 177.
McNeur, A. J., 1953: *Proc. N.Z. Grassld Conf., 15*: 157.
Moule, G. R.; Braden, A. W. H.; Lamond, D. R., 1963: *Anim. Breed. Abstr., 31*: 139.
Rae, A. L.; Brougham, R. W.; Glenday, A. C.; Butler, G. W., 1963: *J. agric. Sci., Camb., 61*: 187.
Reis, P. J.; Schinkel, P. G., 1963: *Aust. J. biol. Sci., 16*: 218.
————, 1964: *Aust. J. biol. Sci., 17*: 532.
Sinclair, D. P.; Clarke, E. A.; Filmer, J. F., 1956: *Proc. N.Z. Soc. Anim. Prod., 16*: 23.
Tocher, K. D., 1952: *Biometrika, 39*: 109.