NUTRITIONAL CONSEQUENCES OF MANIPULATING DURATION AND FREQUENCY OF ACCESS TO LEGUME FORAGE SUPPLEMENTS FOR LOW QUALITY ROUGHAGES

R.M.DIXON[a], R.I.MANI[ab] P.DEVAHUTI[ac] and B.J.HOSKING[a]

SUMMARY

Time of access was examined as a means to regulate intake of supplementary legume forage by sheep fed low quality roughage ad libitum. In Experiment 1 sheep held in individual pens were fed a basal diet (1:1 oat hay and oat straw) ad libitum and were also offered lucerne hay for 0, 0.5, 1, 2, 4 or 24 h each day. Lucerne DM comprised 44% of total DM intake when sheep had access to lucerne for 0.5 h per day, and this increased to 53-56% as access to lucerne was increased up to 4 h per day. Total DM intake increased 25-40% by access to lucerne for 0.5 to 4 h per day, and by 78% by ad libitum access. In Experiment 2 sheep held in metabolism crates were fed oat hay ad libitum either alone or supplemented with lucerne offered at four intervals; 200g each day, 600g each third day, 1200g each sixth day or 2400g each twelfth day. DM intake, OM digestibility, DOM intake, LW change and wool growth were all substantially increased ($P<0.05$) by lucerne supplement, irrespective of interval of supplementation. Increasing interval of offering lucerne decreased total DM intake and DOM intake by 14% ($P<0.05$), but LW change and wool production were not significantly different. The experiments suggest that to restrict the intake of a legume forage by sheep to a small proportion of total intake appropriate for example to meet rumen degradable nitrogen requirements of a low quality roughage, the sheep would have to be given access to the legume forage for short periods each several days. Consumption of the legume forage at intervals of several days would be likely to have only a small negative effect on nutrient intake and productivity.

INTRODUCTION

There is increasing interest in the use of better-quality forages as supplements for low quality forages under both developing country smallholder systems (Carangal and Calub 1987; Dixon and Egan 1988) and Australian grazing systems (Elliott and McMeniman 1987). Legume forages can be produced onfarm during the dry season (e.g. browse shrubs, irrigation) and be lower in cost per unit of feed protein than purchased high protein concentrates. The high nutritive value of legume forages suggests that during the dry season they may usefully be considered in feeding systems as scarce high-value feeds which should be allocated in limited quantities to those animals most responsive to small amounts of additional dietary N.

The intake of supplements by grazing animals will usually be determined by the allocation of fixed amounts of supplement to groups of animals. A similar procedure can be used when forages used as supplements are harvested and carried to animals. A useful low-cost alternative for some grazing situations may be to restrict the intake of supplement forage by limiting the time for which the animals are permitted access to the pasture or fodder crop being used as a supplement. However there appears to

a, School of Agriculture and Forestry, The University of Melbourne, Parkville, Vic. 3052.
b, Present address: ILCA, PMB 2448, Kaduna, Nigeria.
c, Present address: Dept Livestock Development, Phaya Thai Rd, Bangkok.

be little information available on the amounts of high-quality forage animals will consume if they can graze such forages for only a limited time, or of the consequences on nutrient intake or animal productivity of providing supplementary forages at intervals for animals grazing lower quality pasture.

The following experiments were undertaken to examine the use of time of access to supplementary legume forage to limit its intake, and to examine the consequences of providing supplementary legume forage at various intervals of up to 12 days for animals fed low quality roughage ad libitum. Experiments 1 and 2 formed part of the postgraduate research programs of two of the authors (RIM and PD respectively).

MATERIALS AND METHODS

Experiment 1

Thirty-six Merino ewes (approximately 12 mo, mean 24.4 SD 3.1 kg) were held in individual pens for 42 days. The sheep were drenched with anthelminthic (Ivomec, MSD) and allocated at random to six treatments. A basal diet (1:1 chopped oat hay and hammermilled oat straw) and mineral mixture was fed ad libitum (approximately 20% excess of anticipated intake) to all sheep. The control sheep were fed this basal diet alone. The other five treatments consisted of supplementation in separate feed bins with lucerne hay for 0.5, 1, 2, 4 or 24 h each day.

Intakes of basal roughage and lucerne were measured each day, and samples of feed taken for subsequent analysis. Sheep were weighed each week. Wool growth was determined by clipping midside patches (100 x 100 mm) on days 14 and 42. Rumen fluid was sampled by stomach tube on days 40 or 41 before feeding and at 2 and 8 h after feeding. Contents of dry matter (DM), organic matter (OM) and nitrogen of feeds were determined by standard procedures (AOAC 1979) and neutral detergent fibre, acid detergent fibre and lignin by the procedures of Goering and van Soest (1970). Ammonia concentration in rumen fluid was determined by steam distillation under alkaline conditions and titration (Bremner and Keeney 1965). Analysis of variance was used to test the effect of treatment on measured variables, and Students t-test was used to make paired comparisons between treatment means.

Experiment 2

Thirty rumen-cannulated wethers (11-15 mo, mean 38.0 kg) were held in metabolism crates. The sheep were drenched with anthelminthic (Ivomec, MSD) and allocated by stratified randomization to five treatments. A basal diet of chopped oat hay and mineral mixture was fed ad libitum (approximately 20% in excess of anticipated intake) to all sheep. The treatments consisted of oat hay alone (T_1), oat hay plus 200 g of lucerne each day (T_2), oat hay plus 600 g lucerne each third day (T_3), oat hay plus 1200 g lucerne each sixth day (T_4), and oat hay plus 2400 g lucerne each twelfth day (T5). The chopped lucerne hay was fed in separate bins. Dietary treatments were imposed for 48 days which constituted four feeding cycles of T5 and a correspondingly greater number of feeding cycles for the other treatments.

Intakes of oat and lucerne hays were measured each day and samples taken for subsequent analysis. Sheep were weighed each 12 days and midside

patches clipped on days 1 and 48 of the experiment. Measurements were made of disappearance of oat hay and lucerne hay DM from nylon bags incubated in the rumen following in general the procedures described by Orskov et al. (1980). Between days 13 and 27 of the experiment nylon bags were incubated in the rumen for 24 h on days 1, 2, 3, 6 and 12 of the 12 day cycle of Treatment 5, and on the same occasions for the other treatments. Hence for the other treatments measurements were repeated for some days of the feeding cycle. Also on day 1 of the feeding cycle nylon bags were incubated in the rumen for 6 h , 24 h and 96 h to determine the rate of DM disappearance. For 0 h incubation estimates bags were soaked in water for 15 min before washing. The rate of disappearance was calculated from the equation $p = a + b\ (1 - e^{-ct})$ where a, b and c were constants, p was the disappearance from the nylon bag after time t, a was the intercept of the disappearance curve at time zero, b was the component of potentially degradable material which would in time disappear and c was the rate of degradation of b. Samples of rumen fluid were also obtained at the intervals used for the 24 h nylon bag DM disappearance measurements.

A total collection of faeces and urine was carried out from day 36 to 48 of the experiment. Analyses of variance where main effects of treatment, block and period were tested was used to test the effect of treatments on measured variables, and the Least Significant Difference test was used to compare treatment means.

RESULTS

Exweriment 1

The chemical composition of the forages are shown in Table 1. Intake (Table 2) of lucerne DM increased progressively from 297 g/d to 408 g/d as time of access to the lucerne was increased from 0.5 h to 2 h each day, but no further increase was observed with access for 4 h each day. Intake of lucerne DM increased further to 840 g/d when lucerne was available ad libitum. Concurrent intake of basal roughage DM decreased progressively from 547 g/d when no lucerne was fed to 304 g/d when sheep had access to lucerne for 1 h per day. There were no differences between the 1 to 4 h access times, but when lucerne was available ad libitum basal roughage intake decreased to 135 g/d. Total DM intake increased ($P<0.05$) by 25% to 40% by access to lucerne for 0.5 to 4 h, and by 78% with ad libitum access. Access to lucerne for only 0.5 h per day enabled the sheep to consume 44% of total DM intake as lucerne, and was increased to only 53-56% when access to lucerne was increased up to 4 h per day.

Table 1. Composition of feeds (g/kg DM)

Measurement	Experiment 1		Experiment 2	
	Oat hay /straw	Lucerne	Oat hay	Lucerne
Dry matter	861	854	863	883
Organic matter	-	-	933	900
Nitrogen	10.5	35.1	6.7	28.8
Neutral detergent fibre	726	447	723	520
Acid detergent fibre	419	327	414	351
Lignin	55	68	39	68

Table 2. Experiment 1. Intake, rumen fluid NH_3-N concentrations, liveweight change and wool growth in sheep fed a basal diet and with access to chopped lucerne hay for various intervals each day (n 6)

Measurement	Time of access to lucerne (h/d)					
	Nil	0.5	1	2	4	24
Intake (g DM/d)						
Basal	547^{a}	386^{b}	304^{c}	337^{c}	356^{bc}	135^{d}
Lucerne	-	297^{a}	380^{ab}	408^{b}	409^{b}	840^{c}
Total	547^{a}	683^{b}	684^{b}	745^{b}	766^{b}	975^{c}
Intake lucerne (% of total)	0	44	56	55	53	86
Rumen NH_3-N(mg N/l)						
Before feeding	21^{a}	59^{b}	60^{b}	71^{b}	58^{b}	91^{c}
2 h after feeding	24^{a}	184^{b}	206^{b}	206^{b}	168^{b}	180^{b}
8 h after feeding	16^{a}	83^{b}	116^{b}	101^{b}	114^{b}	169^{c}
LW change (g/d)	12	38	64	62	69	98
Wool growth (mg/patch/d)	73^{a}	121^{b}	123^{bc}	109^{b}	124^{bc}	152^{c}

Rumen ammonia concentrations were 16-24 mg/l in sheep fed the basal roughage, and access to lucerne increased rumen ammonia concentrations to 58-91 mg/l before feeding and 83-206 mg/l at 2 and 8 h after feeding (Table 2). However there was little difference between the various times of access to the lucerne.

Increased time of access to lucerne and total DM intake were associated with increases in liveweight (LW) change and wool growth (Table 2), and both these production parameters were correlated ($P<0.05$ or $P<0.01$) with both lucerne intake and total intake. However, as observed with intake, there was little effect of varying time of access to the lucerne between 0.5 and 4 h each day.

Experiment 2

The chemical composition of the forages are shown in Table 1. Sheep fed lucerne each day, each third day or each sixth day consumed 97% or more of the offered lucerne within 24 h, but sheep fed 2400 g lucerne each twelfth day consumed on average 51% on Day 1, 40% on Day 2 and the remainder on Days 3 and 4 of the feeding cycle.

Provision of lucerne each day increased ($P<0.05$) intake of oat hay and therefore total DM intake (Table 3). Providing lucerne each day also increased OM digestibility by 14%, digestible organic matter (DOM) intake by 69%, wool growth by 37%, and sheep gained LW rather than losing LW (Table 3). Provision of lucerne each day increased 24 h disappearance of oat DM from nylon bags by 25%, and rate of disappearance of DM by 58% (Table 4). This was associated with increases in NH_3-N concentration in rumen fluid before feeding from 16 to 43 mg N/l, and 6 h after feeding from 5 to 47 mg N/l (Table 5).

The differences due to offering lucerne at the various intervals were in general smaller than the differences between the basal diet alone and lucerne provided each day. There was a reduction ($P<0.05$) in total DM

Table 3. Experiment 2. Intake, digestion and production of sheep fed oat hay alone or with supplements of lucerne offered at various intervals (n 6)

Measurement	Interval of offering lucerne					SED	Prob.
	Nil	200 g /d	600 g /3d	1200 g /6d	2400 g /12d		
Intake (kg DM/12d)							
Oat hay	8.1	10.1	9.2	8.9	8.5	0.7	**
Lucerne	-	2.0	2.1	2.1	2.0		-
Total	8.1	12.1	11.3	11.0	10.5	0.7	**
OM digestibility (g/kg)	496	565	566	541	558	11	**
DOM intake (kg/12d)	3.74	6.32	5.91	5.45	5.44	0.34	**
N intake (g/12d)	57	130	123	121	119	5	**
N in faeces (g/12d)	45	73	62	63	60	5	**
N in urine (g/12d)	18	40	37	36	43	3	**
N retention (g/12d)	-6	17	25	21	16	3	**
LW change (g/d)	-78	11	-7	-1	-1	2	**
Wool growth (mg/patch/d)	67	92	86	87	85	7.7	**

intake by 13% as interval of offering lucerne increased from one day to twelve days, and since virtually all the lucerne was consumed, this was due to differences in oat hay intake (Table 3). OM digestibility was not affected by interval of offering lucerne, and DOM intake decreased by 14% as interval increased from one day to six days. There was no difference in DOM intake between the 6 day and 12 day intervals (Table 3).

The disappearance of oat hay DM from nylon bags over 24 h (Table 4) was not affected by interval of providing lucerne on Day 1 of each feeding cycle, but was increased ($P<0.05$) on Day 2 of the 1200 g/6d feeding cycle and on Day 3 of the 2400 g/12d feeding cycle. On Day 6 of these latter feeding cycles the 24 h DM disappearance* was only slightly less than, and not significantly different to, the 200 g/d interval. Only on Day 12 of the 2400 g/12 d feeding cycle was the 24 h disappearance of oat hay significantly reduced from 457 g/kg to 379 g/kg by increasing interval of offering lucerne.

DISCUSSION

A number of experiments have demonstrated that when low quality roughages are supplemented with legume forages, increasing intakes of legume are associated with increases in total DM intake, DOM intake and animal productivity (Mosi and Butterworth 1985; Suriyajantratong and Wilaipon 1985; Doyle 1989). However, if only maintenance of animal liveweight or reproductive efficiency is required, and if availability of legume forage is limited, then the optimal level of legume fodder intake may be low. For example a level intended for example to meet rumen degradable nitrogen requirements may be highly effective.

Experiment 1 indicated that if lucerne hay were provided for several hours each day these pen-fed sheep were able to consume about half their total DM intake as lucerne. Variation of time of access to lucerne between 0.5 and 4 h each day did not cause a major change in lucerne or total DM

Table 4. Experiment 2. Disappearance of DM from nylon bags incubated in the rumen on various days of feeding cycle of up to 12 days (n 6)

Measurement		Interval of offering lucerne: Nil	200 g /d	600 g /3d	1200 g /6d	2400 g /12d	SED	Prob.
Disappearance over 24 h (g/kg)								
Oat hay	Day 1	369	448	471	465	447	24	**
	2	372	461	470	530	492	20	*
	3	357	469	438	471	523	25	*
	6	380	464		432	439	20	*
	12	368	457			379	22	*
SED		17	21	16	18	20		
Prob.		NS	NS	NS	**	**		
Lucerne	Day 1	615	635	636	624	615	13	NS
	2	616	631	646	645	631	14	NS
	3	632	652	655	658	669	10	*
	6	618	636		645	629	11	NS
	12	619	646			626	6	**
SED		12	9	14	9	15		
Prob.		NS	*	NS	*	*		
Rate of disappearance on day of offering lucerne (% h^{-1})								
Oat hay		1.9	3.0	3.4	3.3	2.9	0.4	*
Lucerne		7.6	11.1	8.6	7.4	7.2	1.0	**

intake, although lucerne intake was only about half that when lucerne was available ad libitum. If the optimal intake of legume forage is less than the animals will consume with access for several hours each day, then one possibility would be to allow the animals access to the legume forage at appropriate intervals of some days rather than each day. Experiment 2 suggested that as interval of offering lucerne was increased up to 12 days, the increases in DOM intake and animal LW gain and wool growth were to a large extent maintained. Even though rumen NH_3-N concentrations in general decreased almost to control diet levels by 6 days after consumption of lucerne supplement, nylon bag 24 h DM disapppearance indicated that rate of oat hay fermentation in the rumen was not adversely affected after 6 days. However in the treatment where lucerne was offered each 12 days, the nylon bag 24 h DM disappearance at Day 12 declined to the value observed for the basal diet where no lucerne was fed. These observations differ from those reported by Egan et al. (1987) where similar levels of lupin grain or sunflower meal supplements were fed to sheep. In this latter experiment rumen NH_3-N concentrations returned to low levels within 60 h of feeding the supplement, and disappearance of basal roughage DM from nylon bags was lower when supplements were given at 3 day intervals rather than each day.

The amount of legume forage consumed by a sheep when the forage is available for only a few hours each day and the availability of nutrients from the legume and basal forages will presumably vary widely with the characteristics and availability of both forages and with animal factors. The rate of ingestion of lucerne of up to 20 g DM/min.50 kg LW observed in Experiment 1 is much higher than is likely to occur with grazing sheep (Hogan et al. (1987). Further investigation in the grazing situation with

Table 5. Experiment 2. Rumen NH_3-N concentration (mg N/l) determined before and 6 h after feeding on various days of the 12 day feeding cycle (n 6)

Measurement	Interval of offering lucerne					SED	Prob.
	Nil	200 g /d	600 g /3d	1200 g /6d	2400 g /12d		
Before feeding							
Day 1	11	34	72	13	12	10	
2	16	38	69	65	82	13	
3	16	39	35	60	125	13	
6	14	54		31	23	15	
12	25	50			18	16	
SED	8	8	14	9	11		
Prob.	NS	NS	**	**	**		
6 h after feeding							
Day 1	6	74	109	168	170	38	
2	7	56	75	71	190	34	
3	6	58	27	27	83	14	
6	3	35		10	6	11	
12	3	13			6	6	
SED	2	12	23	27	27		
Prob.	NS	*	**	**	**		

various combinations of feeds and animals is needed before general recommendations can be made on the application of time of access to forage legume supplements as a means to obtain target intakes of forage supplements. Nevertheless the two experiments reported above suggested that free access to legume forage for several hours at appropriate intervals of up to a fortnight may be an effective practical means to control intake of forage supplements under grazing conditions.

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