CSIRO PUBLISHING

Animal Production Science, 2009, **49**, 248–252 www.publish.csiro.au/journals/an

Evaluation of a remote drafting system for regulating sheep access to supplement

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Abstract. Remote drafting technology now available for sheep makes possible targeted supplementation of individuals within a grazing flock. This system was evaluated by using 68 Merino wethers grazing dry-season, native Mitchell grass pasture (predominantly *Astrebla* spp.) as a group and receiving access to lupin grain through a remote drafter 0, 1, 2, 4 or 7 days/week for 8 weeks. The sole paddock watering point was separately fenced and access was via a one-way flow gate. Sheep exited the watering point through a remote drafter operated by solar power and were drafted by radio frequency identification (RFID) tag, according to treatment, either back into the paddock or into a common supplement yard where lupins were provided *ad libitum* in a self-feeder. Sheep were drafted into the supplement yard on only their first time through the drafter during the prescribed 24-h period and exited the supplement yard via one-way flow gates in their own time. The remote drafter operated with a high accuracy, with only 2.1% incorrect drafts recorded during the experimental period out of a total of 7027 sheep passes through the remote drafter. The actual number of accesses to supplement for each treatment group, in order, were generally less than that intended, i.e. 0.02, 0.69, 1.98, 3.35 and 6.04 days/week. Deviations from the intended number of accesses to supplement were mainly due to sheep not coming through to water on their allocated day of treatment access, although some instances were due to incorrect drafts. There was a non-linear response in growth rate to increased frequency of access to lupins with the growth rate response plateauing at ~3 actual accesses per week, corresponding to a growth rate of 72.5 g/head.day. This experiment has demonstrated the application of the remote drafting supplementation system for the first time under grazing conditions and with the drafter operated completely from solar power. The experiment demonstrates a growth response to increasing frequency of access to supplement and provides a starting point with which to begin to develop feeding strategies to achieve sheep weight-change targets.

Additional keywords: auto-drafting, precision nutrition, rangeland.

Introduction

Remote drafting technology, which is being developed through the Australian Sheep Industry Cooperative Research Centre, allows individual management of sheep grazing as a flock (Rowe and Masters 2005; Rowe and Atkins 2006). This technology allows sheep tagged with radio-frequency identification (RFID) to be automatically drafted on any criteria as they enter or exit water points. Sheep can be separated for different management according to their weight, physiological status, age or gender, or on the basis of presence or absence of RFID tag (e.g. separation of non-tagged lambs or feral goats).

One application of the remote drafting technology is the targeted supplementation of individuals achieved through controlling access to supplement self-feeders. Supplement intake can be controlled by varying the frequency of access to supplement. This approach has the potential to make supplementation under grazing conditions more economical and efficient by providing supplement to only those animals that require it (e.g. Jordan *et al*. 2006).

An earlier series of pen experiments by our group demonstrated proof of concept for a supplementation system based on the remote drafter (Bowen *et al*. 2008*b*). These experiments provided predictive relationships for liveweight change with different frequencies of access to three types of supplement in a system applicable to the remote drafting technology. Additionally, the pen data showed that restricting trough space at the self-feeder down to 5 cm per sheep in the simulated remote drafter supplementation system did not affect sheep liveweight change, allowing the costs of providing self-feeders to be kept to a minimum. Further research to refine and extend understanding of this new supplementation system in the field is now required before this system can be applied to meet animal growth targets under practical feeding situations.

A paddock experiment was conducted to evaluate the remote drafter under grazing conditions. The objective of this experiment was to compare the weight change of Merino wethers allowed access through a remote drafter to lupin grain at five different frequencies: 0, 1, 2, 4 or 7 days/week, over 8 weeks. Aspects of

 10.1071/EA08161 1836-0939/09/030248

this research have been reported in conference proceedings (Bowen *et al*. 2008*a*).

Materials and methods

Animals, experimental design and diets

A grazing experiment was conducted at Rosebank Research Station near Longreach, in central-western Queensland, using medium- to fine-wool Merino wethers (initially 28 months, 56.1 (s.d. 2.10) kg liveweight, $n = 68$) selected from a larger group of uniform age and origin. The wethers were crutched and wigged (wool shorn from around the breech, prepuce, face and eyes) 2 weeks before commencement of the experiment, vaccinated against clostridial disease and scabby mouth (Glanvac 6, CSL Ltd, Parkville, Victoria) and tagged with half duplex RFID tags (Allflex, Brisbane, Queensland). The wethers had been grazing dry-season, native Mitchell grass pasture (predominantly *Astrebla* spp.) before the experiment.

The wethers were stratified by liveweight and allocated at random to one of five treatment groups so that each group had the same average and distribution of liveweight. The treatments were as follows: no access to supplement (Control; $n = 16$), or access to lupins 1, 2, 4 or 7 days/week (Lup1, Lup2, Lup4 and Lup7, respectively; $n = 13$ per group). Supplement access occurred every Thursday for the Lup1 treatment group, every Tuesday and Saturday for the Lup2 treatment group and every Monday, Wednesday, Friday and Sunday for the Lup4 treatment group so that the trough space available per sheep at the supplement self-feeder was kept constant (18.4 cm/sheep). During the 58-day (~8-week; 18 September to 14 November 2007) experimental period, all sheep grazed dry-season Mitchell grass pasture in a 71-ha paddock. The sole paddock watering point was separately fenced and access was via a one-way flow gate. Sheep exited the watering point through a remote drafter (CAWD Engineering, Orange, New South Wales) which drafted the sheep by RFID either back into the paddock or into a supplement yard (11×11.5 m) common to all treatment groups where lupins were provided *ad libitum* in a self-feeder (1.5-t capacity). On their allocated days of supplement access, sheep were drafted into the supplement yard on only their first time through the drafter in that 24-h period. The change-over time for each calendar day was 2400 hours. Sheep exited the supplement yard and returned to the paddock via one-way flow gates in their own time. The remote drafting unit, which included a portal reader and data logger (Allflex, Brisbane, Queensland), was powered completely by solar power (3×60 W, 1×45 W and 1×50 W solar panels linked in parallel with three deep-cycle 95 Ah batteries). An additional portal reader and data logger unit was positioned on both the exit gate from the supplement yard and the exit gate from the drafter to the paddock and these were run with 240 V power.

During an introductory period of 3 weeks, all sheep were adjusted to the basal pasture and the facilities, including movement through one-way flow gates and through the remote drafter. In addition, all sheep were exposed to lupins in the supplement yard for 2 weeks before the start of the experiment at the rate of 29 g/wether, provided every second day. A proprietary non-protein nitrogen (NPN) loose lick (113 g urea equivalent/kg; 440 g CP/kg DM) was gradually introduced by mixing with coarse salt and was provided *ad libitum* in troughs to all sheep in the paddock. For the first 3 days of drafting during the experimental period, the one-way flow gate on the exit from the supplement yard was shut late at night on the preceding day (~2230 hours), and opened at 0900 hours in the morning, to allow the sheep to become familiar with the supplementation system. From Day 4 of drafting, the supplement yard exit gate was left open continually. This experiment was approved by the Queensland Department of Primary Industries and Fisheries Animal Ethics Committee.

Measurements and analytical procedures

The portal reader and data logger sets positioned at the remote drafting unit and at each exit from the system recorded the time that each individual sheep passed through the drafter and when they returned to the paddock. Once per week during the treatment period, all sheep were mustered into portable sheep yards in the experimental paddock and weighed through a Prattley sheep auto-drafter (Prattley Livestock Equipment, Wagga Wagga, New South Wales). Just before weekly weighing, one bulk faecal sample was collected from all sheep in the Control group and stored at $-18°C$ before freeze-drying and analysis for nitrogen (N) content.

Group supplement intake was estimated for the entire experimental period and was determined as the difference between the total lupin grain added to the self-feeder and that remaining at the end of the experimental period. Lupins intake for individual animals and treatment groups could not be determined because of the nature of the feeding system. Subsamples of lupins were taken from the self-feeder every 10 days during the experimental period and bulked for later chemical analysis. Dry-matter (DM) content was determined on duplicate lupin subsamples on every occasion that lupins were weighed in or out of the self-feeder by drying at 80°C until constant weight. The pasture DM presentation yield of the experimental paddock was estimated nine times during the treatment period by, on each occasion, cutting a 1-m^2 quadrat to ~2 cm above ground level near each of 12 steel pickets placed in a grid across the paddock. The direction and distance of the quadrats from each steel picket was predetermined on a random basis. Pasture plants were separated into grasses or forbs for each quadrat. Grass and forbs samples taken during Week 1 of the experiment were bulked across the 12 quadrats for later chemical analysis.

Feed and faecal samples were milled to <1 mm before chemical analyses, which were on a DM basis. Ash content was determined by heating dry samples in an electric muffle furnace (Thermogravimetric analyser TGA-601, LECO Corporation: St Joseph, MI, USA) at 610°C to a constant weight under an atmosphere of oxygen. Samples were analysed for total N content by a combustion method (Sweeney 1989) with an Elementar RapidN combustion analyser (Elementar Analysensysteme GmbH, Germany). Ash-free neutral detergent fibre (NDF) and ash-free acid detergent fibre (ADF) contents were determined with a Fibretec 2021 Fibrecap System developed by Foss Tecator (Foss Tecator 2002*a*, 2002*b*). Crude fibre (CF) was determined by the method of the AOAC (1975) adapted for the Fibretec 2021 Fibrecap System by Foss Tecator (Foss Tecator 2002*c*). Ether-extract (EE), or crude-fat, content was determined by soxhlet extraction by using petroleum ether (boiling-temperature range 40–60°C) for 16 h (Kent-Jones and Amos 1957).

Calculations

For each experiment, the metabolisable energy (ME) content of grass and forbs components in the pasture on offer was predicted by using Eqn 67 from MAFF (1975), with a correction for ash content:

$$\text{ME density} = 13.5 - (0.015\ \text{ADF} + 0.015\ \text{ash}) + 0.014\ \text{crude protein (CP)}$$

The ME content of lupins was predicted by using Eqn 75 from MAFF (1975):

$$\text{ME density} = 0.012\,\text{CP} + 0.031\,\text{EE} + 0.005\,\text{CF} + 0.014\,\text{NFE},$$

where NFE (nitrogen-free extract) = 1000 – (CP + EE + CF + ash).

For both equations, ME density is expressed as MJ/kg DM and all other concentrations are in g/kg DM.

Statistical analyses

The data were analysed as a completely randomised design with the statistical package GENSTAT for Windows, 10th edition (Payne *et al*. 2007). Generalised linear models with a binomial error distribution and a logit link function were fitted to the number of days a sheep accessed the water yard at least once out of the maximum possible days and the number of days a sheep came through the drafter at least once, on their day of allocated access to supplement, out of the maximum possible days. The average number of times individual sheep accessed the water yard per week was analysed by analysis of variance. The average time each sheep spent in the supplement yards (minutes per feeding session) was analysed by analysis of variance weighted with the number of times the sheep presented at the supplement yard. Pair-wise differences between means were tested by a protected least significance difference procedure ($P = 0.05$). Daily linear growth rates for individual sheep were calculated by regression analysis over time. The variance of the Control group was much larger than the variances of the other groups, which were homogeneous (according to Bartlett's test for homogeneity (Snedecor and Cochran 1980)). This higher variance in the Control group was due to two sheep that accessed the water yard only infrequently and had high liveweight losses. As these sheep were not apparently unhealthy, there was no valid reason to exclude them from the dataset. Mean growth rates of the groups, weighted with the reciprocal of their variances, were regressed against actual frequency of access to supplement. Correlations between linear growth rates of sheep with access to supplement and average time spent in the supplement yard were computed for each group. The mean time spent in the supplement yards was regressed against actual frequency of access to supplement.

Results

The average pasture presentation yield in the experimental paddock during the 8-week experimental period was 559 (s.e. 52.4) kg DM/ha. The percentage of the pasture DM on offer that was classified as forbs (non-grass species) averaged 6.5 (s.e. 1.71)%, with the highest recording of forbs during Week 4 of the experiment (18.1% of pasture DM). The chemical composition of the pasture and lupins on offer during the experiment is given in Table 1. The N content of weekly faecal samples taken from the Control sheep fluctuated in line with the proportion of forbs in the pasture (range 10.1–13.8 g/kg DM), with the average faecal N over the experimental period being 11.3 (s.e. 0.38) g/kg DM. If it is assumed that all sheep from all treatment groups consumed equal quantities of supplement at each time of actual access, the average consumption of lupins was 668 g DM/head.access. The amount of NPN loose lick consumed by the sheep during the experimental period was negligible.

The CAWD remote drafter operated with high accuracy during the 8 weeks of the experiment, with a total of 52 instances of sheep being wrongly drafted into the supplement yard and 93 instances of sheep being wrongly drafted into the paddock. Incorrect drafts formed 2.1% of the total number of drafts (7027) during the experiment period.

Sheep from those treatment groups receiving access to supplement entered the water yard at least once per day on a significantly ($P < 0.05$) higher percentage of days than sheep in the Control group (Table 2). Furthermore, the average number of water yard accesses per week was significantly less for sheep in the Control group than for sheep receiving access to lupins 2–7 days/week. The actual number of accesses to supplement for each treatment group was close to that intended. Deviations from the intended number of accesses to supplement were mainly due to sheep not coming through to water on their allocated day of treatment access, although some instances were due to incorrect drafts.

The percentage of days that sheep from the Lup2 group passed through the drafter at least once on their day of supplement access was higher ($P < 0.05$) than for sheep in the Lup4 and Lup7 groups while Lup1 was not significantly different from any of the other treatment groups. A similar trend was evident for the time spent by sheep in the supplement yards, with Lup2 sheep spending significantly ($P < 0.05$) more time in the supplement yards than sheep in Lup4 and Lup7 groups.

The relationship between mean growth rates (29, 52, 69, 69 and 76 g/wether.day for Control, Lup1–7, respectively) and actual frequency of access to lupins per week was described by an exponential equation (Fig. 1). The growth rate plateaued at ~3.0 actual accesses per week, corresponding to a growth rate

Table 1. Estimated metabolisable energy concentration (ME, MJ/kg DM) and concentrations (g/kg DM) of crude protein (CP; N × 6.25), organic matter (OM), neutral detergent fibre (NDF), acid detergent fibre (ADF), crude fibre (CF) and ether extract (EE) in pasture and lupins offered to Merino wethers

	ME	CP	OM	NDF	ADF	CF	EE
Mitchell grass pasture[A]							
Grasses	6.6	43.8	901	669	402	–	–
Forbs	6.6	101	827	519	379	–	–
Lupins	12.8	335	973	–	–	135	62

[A]Pasture was sampled during Week 1 of the experiment.

Table 2. Effect of allocated frequency of access to lupins supplement on the actual frequency of sheep entry to both the water and supplement yards and on the time spent by sheep in the supplement yard

Values within rows followed by different lowercase letters are significantly different at $P = 0.05$

	Treatment					s.e.d.[A]
	Control	Lup1	Lup2	Lup4	Lup7	
Logit (% of days sheep accessed the water yard at least once per day)	1.6a (83)	2.5b (92)	2.6b (93)	2.3b (91)	2.4b (92)	0.19
No. of water yard accesses per week	11.0a	12.7ab	14.9b	13.5b	13.4b	1.08
Logit (% of days sheep passed through the drafter at least once on their day of supplement access)	–	2.8ab (94)	4.2b (98)	2.0a (88)	2.4a (92)	0.52
No. of supplement yard accesses per week	0.02	0.69	1.98	3.35	6.04	
Time in supplement yard (min per feeding session)	–	13.1ab	14.4b	9.6a	8.8a	2.66

[A]Average of all treatment groups.

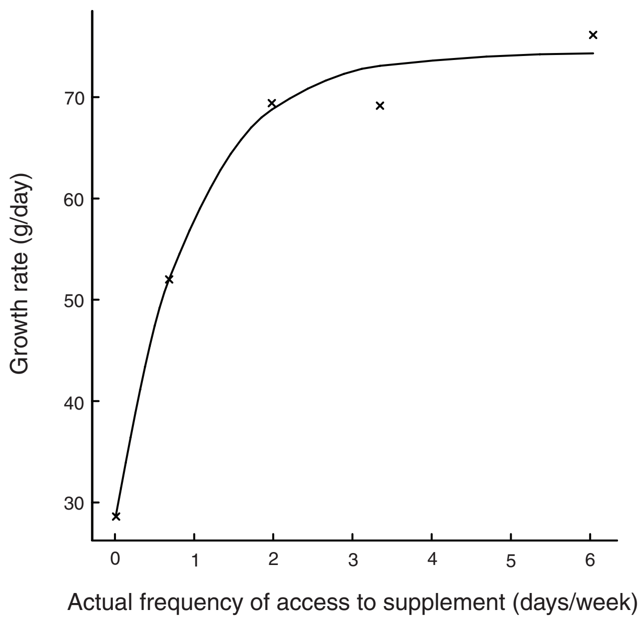

Fig. 1. Mean growth-rate response to actual frequency of access to supplement: $y = 74.4$ (s.e. 2.32) – 46.3 (s.e. 6.27) × 0.345 (s.e. 0.0896)^x, (adjusted $r^2 = 0.94$, $P = 0.030$).

of 72.5 g/head.day. There were no significant correlations between sheep growth rate and the average time spent in the lupin supplement yard for any of the groups (Lup1, Lup2, Lup4 or Lup7; r = –0.09, 0.51, 0.34, 0.29; P = 0.80, 0.08, 0.26, 0.33, respectively). When the mean time spent in the supplement yard for groups was regressed against actual frequency of access to the supplement yard, the relationship was not significant, although about half of the variation was explained.

Discussion

This experiment has demonstrated that the CAWD remote drafter operated with high accuracy, over a period of 8 weeks, when operated completely from solar power. Although the actual number of accesses to supplement for each treatment group was generally less than that intended, i.e. 0.02, 0.69, 1.98, 3.35 and 6.04 days/week *v.* 0, 1, 2, 4 and 7 days/week, this was mostly a result of sheep not coming through to water on their allocated day rather than a result of incorrect drafts.

As previously observed in pen experiments (Bowen *et al.* 2008*b*), the time spent by sheep in the lupin supplement yard tended to decrease as access was provided more frequently. It is possible that this may have contributed to the non-linear liveweight response observed in the present experiment to increased frequency of access to lupins, where the response curve plateaued at 3 days of actual accesses per week. However, this response is in contrast to the linear response relationships observed in the pen experiments. As it was not possible to measure supplement intake by individual animals in the current experiment, or the pen experiments, it is impossible to determine whether the time spent by sheep in the supplement yard was correlated with intake. When individuals within treatment groups were examined, there was a lack of any correlation between liveweight change and time spent in the lupin supplement yard.

The non-linear response to increasing frequency of supplement access could also be a result of greater substitution of lupin grain for pasture when lupins were provided more frequently so that total ME intake may have not increased substantially when lupins were offered more frequently than 3 days of actual accesses per week. Substitution rates usually increase as the nutritive value and leaf content of forage improves and the ability of grazing sheep to select a better-quality diet than pen-fed sheep may have led to a greater substitution rate of lupins for forage under the grazing conditions than under the pen conditions. Similarly, Freer *et al.* (1988) concluded that the higher substitution rate exhibited by grazing than by yarded lambs at moderate to high levels of supplementation (Freer *et al.* 1985) was a result of the higher quality of the roughage consumed by grazing animals rather than differences in eating behaviour between grazing and yarded animals. However, the plateau in growth rate response in the present experiment at the relatively low level of 72.5 g/wether.day was unexpected, given that the growth rate response to lupins access in the pen experiments did not appear to have plateaued at 127 and 155 g/wether.day (Experiments 1 and 2, respectively). Nevertheless, the sheep in the pen experiments were younger and had lower initial liveweights (Experiment 1: 13 months, 49 kg liveweight; Experiment 2: 21 months, 49 kg liveweight) than those in the present experiment (28 months, 56 kg liveweight), and this may have influenced the result.

The high variance in growth rate of sheep in the Control group, owing to the two sheep that accessed the water yard only infrequently and had high liveweight losses, could possibly be due to these sheep having an aversion to the remote drafting facilities that were associated with the water yard and, without the incentive of supplement access, being less inclined to enter the water point. Similarly, Lee *et al*. (2008) found that sheep with no access to supplement made fewer ($P < 0.05$) recorded passes through a remote drafting system than those allowed access to supplement every third day or daily.

Dixon and Hosking (1992) reported a range in supplement conversion efficiency of 0.2–0.8 g liveweight change/g grain legume DM, with the level of response to grain legume supplement apparently inversely related to the growth rate of unsupplemented animals, and hence to the quality of their basal roughage diets. The estimated efficiency of supplement conversion in our experiment was at the lower end of this range, being 0.15 g liveweight change/g lupin DM where the response relationship between growth rate and frequency of supplement access reached plateau (Fig. 1). This value was similar to values estimated in pen experiments (Bowen *et al*. 2008*b*) for sheep offered supplement 7 days/week, where the efficiency of supplement conversion ranged from 0.16–0.20 g liveweight change/g lupin DM.

In conclusion, the present experiment has demonstrated application of the remote drafting supplementation system for the first time under grazing conditions, with the drafter being operated completely from solar power. However, under different conditions of basal roughage, supplement type, paddock and group size, climatic conditions and sheep characteristics it is probable that sheep behaviour and supplement intake will differ from that documented in the present experiment. Further research is required before this technology can be applied confidently in commercial situations to achieve sheep growth targets.

Acknowledgements

This experiment was funded by the Australian Sheep Industry Cooperative Research Centre with in-kind contributions from the Department of Primary Industries and Fisheries, Queensland (DPI&F). We are grateful to Peter Martin, Adam Pytko and Madeleine Modina of the Health and Nutritional Biochemistry Laboratory of DPI&F for conducting laboratory analyses.

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Manuscript received 8 May 2008, accepted 20 November 2008