Targeted conservation grazing using molasses to increase preferential consumption of old growth pasture grasses

Ian. D. Grange*

School of Agriculture, Food and Environment, Royal Agricultural University, Gloucestershire, GL7 6JS, UK.

SUMMARY

High conservation value grasslands, which are usually marginal and agriculturally poor, are often difficult to manage appropriately for biodiversity enhancement. A key management tool for this is conservation grazing, by which grazing intensity, timing and duration can be altered to suppress certain plant species, such as the more dominant grasses without impacting on other less competitive herbaceous ones. It has been suggested that the application of molasses to plant leaves could effectively encourage livestock to consume old and rank pasture grasses. This study assessed whether such an approach could be adapted to UK conservation grasslands, by using molasses to target grazing towards problem areas of dominant grass species. When Dexter cattle were exposed to areas of upright brome *Bromopsis erecta* and wood false-brome *Brachypodium sylvaticum* that had received a single application of molasses in the autumn period, no preference was shown for the treated plants. In the late winter period, however, cattle showed a significant preference for upright brome plants that had received two applications of molasses. Therefore, if consideration is given to the timing and frequency of molasses applied to target vegetation, it can be used as a conservation grazing management tool for some less palatable grasses.

BACKGROUND

Unimproved lowland grassland coverage has undergone a dramatic decline in recent decades (Carey *et al.* 2008). This has often been accompanied by a decrease in the inherent floral biodiversity within remaining grassland areas, due to a range of factors, including management change (Critchley *et al*. 2004). Under-grazing, or cessation of grazing through abandonment, has led to increases in dominant grasses such as upright brome *Bromopsis erecta (*syn. *Bromus erectus)* and, in more wooded or scrub containing areas, wood false-brome *Brachypodium sylvaticum* (Willems 2001). Such grasses can become spatially dominant, overtopping most of the accompanying subordinate species and outcompeting them for light, leading to the disappearance of many (Mitchley & Grubb 1986).

Conservation grazing is a key management tool controlling dominant grasses, and has helped restore grassland biodiversity in many instances. The issue of low palatability, however, deters selective feeders away from the tough fibrous grasses toward other more appetising herbage (Peeters 2004). Crofts and Jefferson (1999) describe two approaches to achieve effective grass management through grazing: 1) Use higher stocking densities for shorter periods to graze those grasses when they are actively growing in the spring, or, 2) Graze at lower densities over a longer time period. However, both approaches still risk potential grazing damage to the preferred, non-target plant species, for example through interference with annual seed production.

An alternative approach to encourage grazing stock to eat less palatable grasses has been through the use of molasses. In addition to being a palatability enhancer, molasses is extensively used as a feed nutrient supplement, as well as a binding agent in compound feeds (Heuzé *et al.* 2012). It has long been recognised that in the seasonally drier pasturelands of the USA, Australia and Africa, spraying molasses onto any remaining low quality forage markedly improves its palatability and hence uptake, preventing loss of livestock weight and condition (Graber 1936, Beames 1960, Coombe & Tribe 1962). Indeed, Cleasby (1963) stated that cattle and sheep were readily attracted to molasses and Graber (1936) described how cattle created channels of grazed pasture where the molasses had been applied in lines from the back of a truck.

Similar uses have been made of molasses to encourage selective grazing of invasive weed species, with mixed results. Doran (no date) found that molasses sprayed directly onto medusahead *Taeniatherum caput-medusae*, an invasive pasture grass in California, did not encourage sheep to eat more than the untreated plants. However, when the stock were confined in a yard and fed with the same plant fodder that had been cut, chopped and mixed with molasses, they 'developed a taste' for and consumed it. Thereafter, on their return to the field, they readily consumed the sprayed grass. Voth (2007) has suggested a systematic method of training livestock to help them acquire tastes for less palatable plants, using molasses as a palatability enhancer.

The objective of this work was to determine whether strategic applications of molasses to patches of target vegetation considered to be problematic would encourage preferential grazing of these patches over surrounding vegetation. In order to assess this we examined the effects of cattle grazing on *B. erecta* and *B. sylvaticum* dominated grasslands, both with and without molasses treatments.

ACTION

The experimental site was at Miserden, Gloucestershire, England (OS grid reference SO 948084), about 10 miles northwest of Cirencester. The area is on the Cotswold plateau scarp, which gently slopes in a westward direction away from the Cotswold escarpment to the east and has an elevation of about 150 m a.s.l. The experimental site has a mean annual

*To whom correspondence should be addressed: ian.grange@rau.ac.uk

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rainfall of 759 mm and mean maximum temperature of 14°C and minimum temperature of 6°C.

Five individual experiments were carried out to test the effectiveness of molasses in different habitats and with varying application treatments (E1 to E5, Table 1). Sites E1, E2 and E3 were dominated by freely draining, shallow, lime-rich soils over limestone (NSRI 2012), belonging to the Sherbourne Series (Findlay *et al*. 1984). Whilst each fell within CG5 *Bromus erectus-Brachypodium pinnatum* grassland of the National Vegetation Classification (NVC) (Rodwell 1992), E1 had notable inclusions of cock's-foot grass *Dactylis glomerata* and downy oat-grass *Avenula pubescens*. *B. erecta* was dominant in E2 and E3, probably as a result of reduced grazing in the past (Austin 1968), along with inclusion of *A. pubescens*.

E4 and E5 were located on a gentle west-facing slope, consisting of unimproved limestone to neutral grassland. Within the NVC, these sites are described as 'Woodlands and scrub' with a significant influence of *B. sylvaticum* between scattered scrub (W21c, *Crataegus monogyna-Hedera helix* scrub, *Brachypodium sylvaticum* sub-community) (Rodwell 1991). Hereafter, this habitat is described as 'woody grassland'. This site consisted of lime-rich loamy and clayey soils with impeded drainage (NSRI 2012), belonging to the Evesham 1 Soil Association (Findlay *et al*. 1984).

Dry matter (DM) was estimated using the Farmworks Rising Plate Meter F200 (Farmworks Systems Ltd, New Zealand). The calibration used throughout (plate reading x 125 + 640) was that recommended by Powell (2014) as being suitable for British pastures; that is, where the 'plate reading' is the average compressed sward height, 125 is the 'multiplier', which reflects the percentage of DM in the grassland (i.e. 12.5%), with the 640 being the 'adder' which compensates for the amount of grass at the bottom of the sward that is not measured by the plate meter. Whilst it was recognised that this approach would not necessarily give an accurate representation of the exact DM in the variety of grasslands found in this work, it would nevertheless give relative estimates of DM change due to effects of grazing. Each reading reported and used for analysis in this work was a mean of 30 separate readings made in the field plots.

The management regime of the site consisted of very light conservation grazing with four Dexter cattle in the autumn; in the late winter two more were added to the same group to make

Table 1. Experimental design and molasses treatment at each site in the study; DM = dry matter.

Site number (livestock present)	Experimental design	Molasses application rate (g/m²) ±95% C.I. [1]	Dates of molasses application and number of days between DM measurements [2]	Replicate plot size	Number of DM plate meter readings/plot [3]	NVC community[4]
E1 Cattle (4 Dexters)	Fully randomized design with 3 treatments each with 8 replicates: upper rate molasses, lower rate molasses and control.	Upper rate: 27.3 ± 1.7 Lower rate: 13.7 ± 0.8	Autumn application 6/11/14 to 9/11/14 = 3 days	2m × 2m	1	CG5
E2.1 Cattle (6 Dexters)	Three blocks of randomized design with 2 treatments replicated 4 times: single rate molasses and control treatments.	18.9 ± 0.9	1st application in Late-winter 25/2/15 to 28/2/15 = 3 days	3m × 3m	3	CG5
E2.2 Cattle (6 Dexters)	Using the same experimental plots as for E2.1, a second application treatment of molasses was added.	24.3 ± 1.48	2nd application in Late-winter 28/2/15 to 2/3/15 = 3 days	3m × 3m	3	CG5
E3.1 Cattle (6 Dexters)	Fully randomized design with 2 treatments each with 4 replicates: single rate molasses and control. As the target grasses were growing in a circle, replicate plots were designed in an octagonal shape with 8 randomly allocated replicates in the shape of triangular 'pie slices'.	8.9 ± 0.6	1st application in Late-winter 6/2/15 to 8/2/15 = 2 days	4.58 m²	3	CG5
E3.2 Cattle (6 Dexters)	Using the same triangular experimental plots as for E3.1, a second, larger application of molasses was added.	27.9 ± 1.4	2nd application in Late-winter 8/3/15 to 10/3/15 = 2 days	4.58 m²	3	CG5
E4 Cattle (4 Dexters)	Fully randomized design with 2 treatments each with 3 replicates: single rate molasses and control.	24.1 ± 0.4	Autumn application 20/11/14 to 27/11/14 = 7 days	3m × 3m	2	W21c
E5 Cattle (6 Dexters)	Fully randomized design with 2 treatments each with 5 replicates: single rate molasses and control.	27.9 ± 1.4	Late-winter application 8/3/15 to 10/3/15 = 2 days	3m × 3m	1	W21c

[1]To convert molasses application rates from g/m² to tonnes/ha, multiply figures by 10.
[2]Molasses was applied on the first date indicated, with DM measurements carried out on the first and second date indicated (before and after grazing, respectively).
[3]Each of these plate meter readings is the mean of 30 individual measurements around the plot.
[4]Rodwell 1991, 1992

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a total of six. Stocking rates were between 0.05 to 0.08 LU/ha. Cattle were integrated into a series of small experiments (Table 1). Camera traps were set up on each experiment to help monitor grazing activity.

Sugar cane molasses, containing 44.3% total sugars (as sucrose) was used (NAF, Wonastow Rd, Industrial Estate West, Monmouth). It was applied with a bamboo cane repeatedly dipped into a tub of molasses, to the same depth each time, and then quickly withdrawn and sprinkled across the plot before wiping off the remaining molasses on the vegetation leaf surfaces. In order to estimate application amounts, the same procedure was conducted in the laboratory, repeatedly (n = 8) weighing the applications to obtain a mean application estimate ± 95% confidence interval. Application rates for E1 to E5 were then calculated and reported as g/m^2 (Table 1). Since the molasses was not diluted and remained quite viscous, the occasional low rainfall events that did occur after applications were not considered sufficient to remove it from leaf surfaces, with this assumption being supported by observation. However, the timing and incidence of heavier rainfall events should be a consideration in future management work.

Mean DM values and associated 95% confidence limits before and after grazing were presented graphically for each of the experiments (Figures 1 to 5). The Q-Q Plot approach was used to confirm that data were normally distributed. Statistical tests were then conducted using Microsoft Excel 2010 and Genstat (Genstat 2015). ANOVA and two sample t-tests were used to compare DM values, after confirming equal variances using the paired two sample F-test. Bonferroni corrections were applied to accommodate for multiple comparisons in Experiments E1-E4. The general approach was to first assess for any differences between the initial DM values before grazing, then to compare these initial values with corresponding grazed values, followed by comparison between grazed treatment plots.

CONSEQUENCES

At experimental site E1 (Table 1), with *B. erecta* along with *D. glomerata* and *A. pubescens* representing CG5 of the NVC (Rodwell 1992), there were no significant differences in DM values between the treatment plots prior to being grazed by cattle ($F_{2,22} = 0.24$, p = 0.79), as expected (Figure 1). After three days of grazing by four Dexter cattle, there was significantly less DM compared to before grazing for all treatments (control: t(two-tailed) = 3.26, p = 0.0049; high rate molasses: t = 4.14, p = 0.0010; and low rate molasses: t = 3.92, p = 0.0016). There was no significant difference in DM between the treatments after three days of cattle grazing ($F_{2,\ 22} = 0.58$, p = 0.57), indicating that the whole site had been uniformly grazed (Figure 1). A Bonferroni correction for multiple comparisons confirmed these findings (Table 2).

Table 2. Mean dry matter values, for calcicolous grassland of CG5 before and after cattle ‘autumn’ grazing (4 Dexters), following two treatments with molasses (Experiment E1, Table 1).

Treatment	Mean DM values (kg/ha)*	
	Before grazing	After grazing
Control plots	1912 bc	1704 a
Molasses plots: upper rate	1949 c	1744 ab
Molasses plots: lower rate	1955 c	1688 a

*Different letters indicate significant differences in DM between treatments after Bonferroni correction for multiple testing was applied.

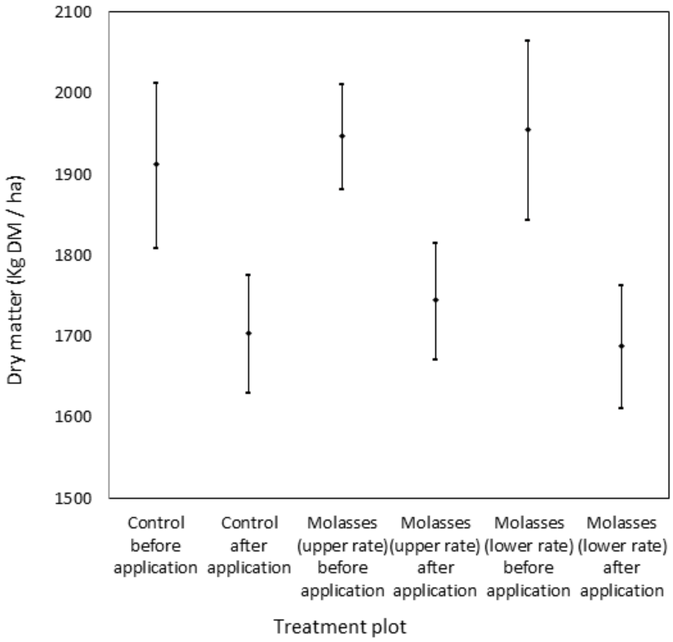

Figure 1. Mean dry matter values (± 95% C.I.) for CG5 grassland before (6 November 2014) and after (9 November 2014) ‘autumn’ cattle grazing (4 Dexters), following treatments with molasses (Experiment E1, Table 1).

Repeated molasses treatments on three blocks within the calcicolous grassland of CG5 (Experiment E2, Table 3) demonstrated: a) no significant difference in DM quantities between treatments prior to molasses application, as expected (t = 0.68, p = 0.50), b) no significant difference in DM quantities between initial non-grazed sward and after the first application of molasses (Control: t = 1.76, p = 0.11 and Molasses: t = 1.48, p = 0.17), and c) significant reduction in DM in the molasses treated plots after the second application, compared to the control (t = 8.30, p = <0.0001) (Table 3 and Figure 2).

Experiment E3 considered a broadly circular patch of *B. erecta*-dominated vegetation growing amongst *A. pubescens* (CG5). As expected, the initial DM values for all plots were not significantly different (t(two-tailed) = 1.34, p = 0.21). After four days of grazing by six Dexter cattle, there was significantly less DM compared to before grazing for each of treatment (control: t = 13.56, p < 0.0001, first molasses application plots: t = 11.12, p < 0.0001, and the second molasses application plots: t = 17.35, p < 0.0001). When comparing the grazed DM values between the first and second application molasses plots and the control plots, a significant difference was only found for the second

Table 3. Mean dry matter for calcicolous grassland of CG5 before and after ‘Late-winter’ cattle grazing (6 Dexters) following two treatments with molasses (Experiment E2, Table 1).

Treatment	Mean DM values (kg/ha)*		
	Before grazing	After 1st application	After 2nd application
Control plots	2012 c	1945 c	1739 b
Molasses plots	1992 c	1868 bc	1549 a

*Different letters indicate significant differences in DM between treatments after Bonferroni correction for multiple testing was applied.

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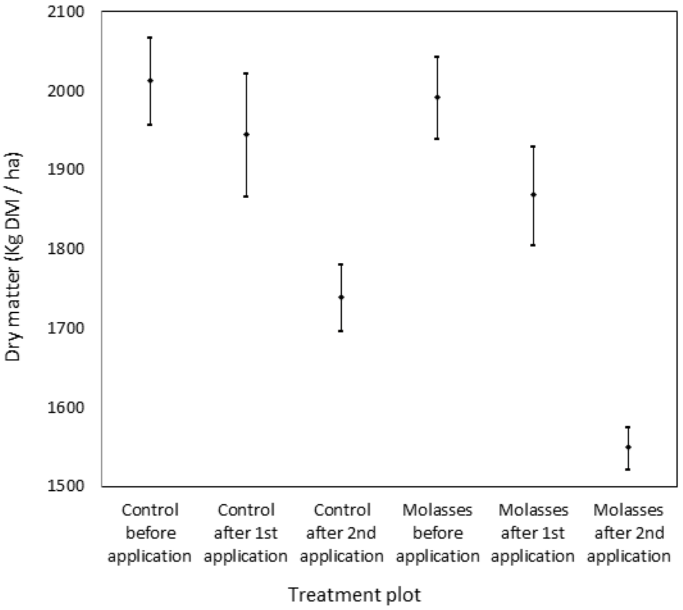

Figure 2. Mean dry matter values (± 95% C.I.) for calcicolous grassland of CG5, before (25 February 2015) and after 'late-winter' cattle grazing (6 Dexters) following first (27 February 2015) and second (2 March 2016) applications of molasses (Experiment E2, Table 1).

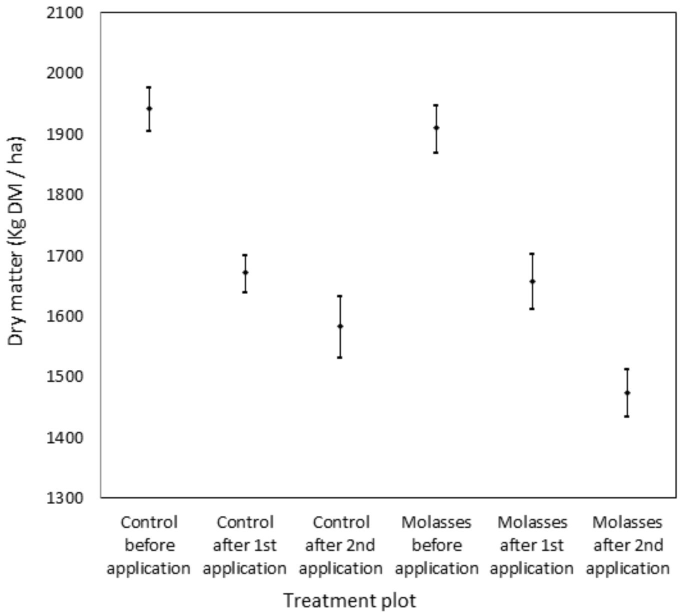

Figure 3. Mean dry matter values (± 95% C.I.) for calcicolous grassland of CG5 before (6 March 2015) and after 'late-winter' cattle grazing (6 Dexters) following first (8 March 2015) and second (10 March 2015) treatments with molasses (Experiment E3, Table 1).

application treatment (t = 0.52, p = 0.61 and t = 3.58, p = 0.0044, respectively, Figure 3). A Bonferroni correction for multiple comparisons confirmed these findings (Table 4).

On another site (Experiment E4, Table 1), representing the W21c community of the NVC (Rodwell 1991) where the less palatable *B. sylvaticum* grass was dominant, the grazing impact of cattle was again assessed (Table 5, Figure 4). For this site, there was already an initial difference between the DM amounts in the control and molasses treated plots prior to grazing (t(two-tailed) = 3.04, p = 0.012). After seven days of grazing, there were significant reductions in DM amounts for both the control and molasses plots compared with the starting amounts (t = 14.34, p < 0.0001 and t = 7.98, p < 0.0001, respectively, Figure 4). A Bonferroni multiple comparison test confirmed these findings (Table 5). Whilst molasses treated plots of Experiment E4 did show significantly less remaining DM after 7 days of grazing compared to the control plots (p(two-tailed) = 0.0009), this could simply be related to a uniform reduction in DM proportional to the initial DM amounts. That is, the control and molasses treatments were reduced by 1029 and 940 kg DM / ha, respectively.

The final Experiment E5 was conducted on the W21c woody grassland dominated by *B. sylvaticum*. Using the same analysis as for the previous experiments, there were no significant differences in DM values between the treatment plots prior to being grazed by cattle (t = 0.66, p = 0.53), as expected (Figure 5). After two days of grazing with six Dexter cattle, whilst there was significantly less DM in the molasses treated plots compared to the same plots before grazing (t = 3.11, p = 0.015), there was no difference in quantity of DM between the molasses-treated plots and the control plots after grazing (t = 1.44, p = 0.19).

Table 4. Mean dry matter values, for calcicolous grassland of CG5 before and after cattle 'late-winter' grazing (6 Dexters), following two treatments with molasses (Experiment E3, Table 1).

Treatment	Mean DM values (kg/ha)*					
	Before grazing		After 1st application		After 2nd application	
Control plots	1943	c	1671	b	1583	b
Molasses plots	1910	c	1657	b	1474	a

*Different letters indicate significant differences in DM between treatments after Bonferroni correction for multiple testing was applied.

DISCUSSION

Molasses has traditionally been used outside the UK for livestock as a palatability enhancer on old growth pasture, often used in the dry season or during times of drought to maintain uptake of poor quality roughage (Graber 1936, Beames 1960, Coombe & Tribe 1962, Heuzé *et al*. 2012). The work presented here considered how such an approach could be adapted to targeting conservation grazing management towards patches of less palatable grasses, which tend to become dominant and reduce the biodiversity value of conservation grasslands. Whilst plants such as *B. erecta* and *B. sylvaticum* are not introduced species, they have sometimes been described as "aggressive invaders" (Bobbink & Willems 1987) due to their ability to

Table 5. Mean dry matter values, for W21c woody grassland (Experiment E4, Table 1), before and after cattle 'autumn' grazing (4 Dexters), following treatment with molasses.

Treatment	Mean DM values (kg/ha)*			
	Before grazing		After application	
Control plots	3231	d	2202	b
Molasses plots	2838	c	1898	a

*Different letters indicate significant differences in DM between treatments after Bonferroni correction for multiple testing was applied.

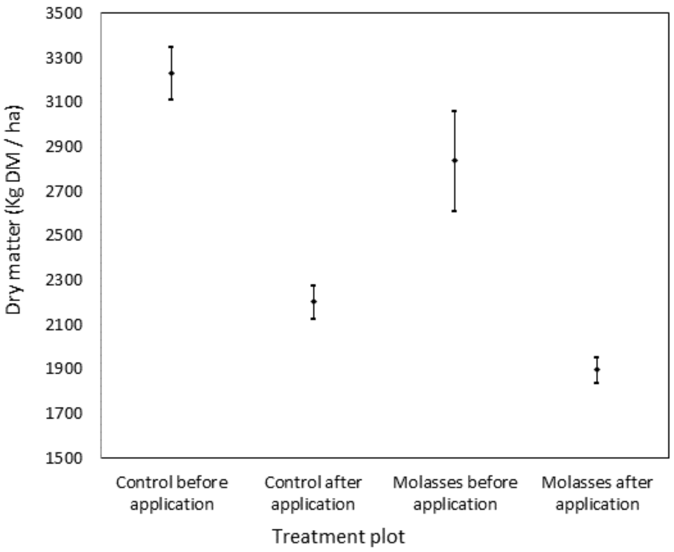

Figure 4. Mean dry matter values (± 95% C.I.) for W21c woody grassland, before (20 November 2014) and after (27 November 2014) cattle 'autumn' grazing (4 Dexters), following treatment with molasses (Experiment E4, Table 1).

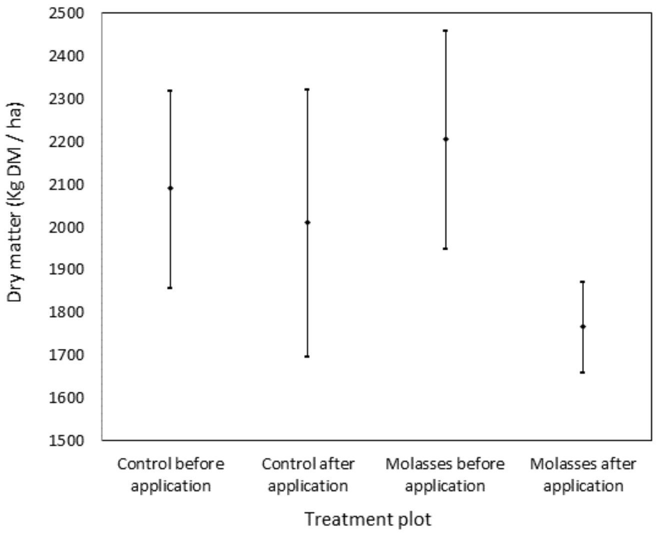

Figure 5. Mean dry matter values (± 95% C.I.) for W21c woody grassland (Experiment E5, Table 1), before (8 March 2015) and after (10 March 2015) cattle 'late-winter' grazing (6 Dexters), following treatment with molasses.

expand their spatial coverage after a change in environmental conditions.

Some useful insights have come from this series of preliminary grazing experiments testing a molasses amendment. For calcicolous grassland, lying within the CG5 NVC community, *B. erecta* dominated grass patches were preferentially grazed when treated with molasses. However, a significant reduction in DM only occurred after a second application of molasses was made (Tables 3 and 4, Figures 2 and 3). It was not clear why this additional encouragement was needed, but could be related to cattle 'developing a taste' for molasses and / or the specific grasses. Voth (2007) discussed how cattle acquired a taste for certain plant species that they would not necessarily consume in the first instance, by implementing a training programme using molasses as a palatability enhancer. The results of the two experiments that had two applications of molasses (E2 and E3, Table 1) add weight to the notion that sequential applications might be important to enhance effective uptake of less palatable grasses.

Whilst *B. erecta* is considered to be moderately palatable to both cattle and sheep (Peeters 2004), when given the choice, they prefer other more appetizing and nutritious plant species (Hope-Simpson 1940). Experiment E3 demonstrated that, in late winter, cattle could be induced to preferentially graze patches of *B. erecta* that had been sequentially treated with molasses. In contrast, *B. sylvaticum* is considered to be highly unpalatable (Crofts & Jefferson 1999), making it more of a grazing challenge, particularly when it is old and rank. Adding molasses to patches of *B. sylvaticum* was not conclusively shown to encourage increased consumption by Dexter cattle. Whilst others outside the UK have reported molasses as a very useful amendment in encouraging livestock to consume poor quality roughage, this did not appear to be the case in these W21c grass patches during the autumn and late winter period (Experiments E4 and E5, Figures 4 and 5). Whilst the molasses-treated grasses were grazed, the adjacent non-treated plots tended to be equally grazed. Unlike the CG5 grassland (Figure 2 and 3), the W21c woody grassland only received a single molasses application. It is therefore possible that a second application to the W21c woody grassland could have encouraged cattle to preferentially graze more of the treated *B. sylvaticum* patches, but this would need to be confirmed through further field studies.

A similar finding was seen in the CG5 grassland of Experiment E1 (Figure 1), where *A. pubescens* and *D. glomerata* were present alongside *B. erecta*. The nutritive value of *A. pubescens* is unclear (Dixon 1991), but likely to be poor to average (Peeters 2004), with Hubbard (1992) also reporting it as being of minimal value as a fodder plant. Whilst *D. glomerata* has been reported as being both palatable and unpalatable, depending on protein content and variety (Heuzé & Tran 2014), Peeters (2004) also noted that it is only readily accepted at a leafy stage and is rejected later in a more lignified, tufted growth stage. At the time of this experiment in a relatively mild autumn, the grasses may have remained relatively more palatable for longer. This assumed palatability may have led to the non-significant differences between plots with and without molasses applications, even where application levels were high (Figure 1). More work on relative grass palatabilities and their interactions with molasses amendments is needed. It is possible to speculate that the molasses treated grasses were preferentially grazed, before cattle then moved onto the untreated plots that were still quite palatable, though this would be difficult to confirm without additional work shortening the time period between molasses application and measurement to better distinguish any difference that might have occurred.

The apparent transition from a weak relationship between preferential grazing of the molasses treated grasses in the autumn period to a more conclusive link between cattle preferring to eat molasses treated grasses in the late winter was probably due to a combination of factors. Having never been fed molasses before, cattle may have needed time to familiarise themselves with it, at least in the initial stages. In addition, at the end of a relatively mild autumn, there may still have been preferential grazing of other remaining, more succulent fodder plants, leading cattle to ignore the molasses treated plots. By late winter, with cattle having now 'acquired the taste' for molasses and with fewer of the more palatable plants being available, preferential grazing of molasses treated grasses was then observed. There may also have been an element of cattle 'acquiring a taste' for the fodder plants themselves as a result of the molasses treatment encouraging grazing.

In conclusion, it was shown that sequential applications of molasses in late-winter could be used to encourage cattle to graze off the excess grassy thatch in selected grass patches, with the aim of encouraging other plant diversity. To better characterise these preliminary findings, it is suggested that: a) problem plants in semi-natural grasslands be identified and prioritized, b) seasonal/annual effects of molasses applications to these plants be better assessed with specific focus on sequential applications, c) depending on the efficacy of the relationship in (b) above, methods of application be refined to include mechanical sprayers, and d) a cost-benefit evaluation be conducted. However, on the basis of the current study, which only strategically targeted relatively small areas of problem plants, a positive cost-benefit would be anticipated.

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