Frequency distribution of sward height on pastures grazed by cattle alone or co-grazed with sheep

S.M. KITESSA AND A.M. NICOL

Animal and Veterinary Sciences Group, Lincoln University, P.O. Box 84, Lincoln, Canterbury, New Zealand.

ABSTRACT

Pasture height is increasingly employed in feed planning as a measure of pasture availability. The frequency distribution of pasture height on a ryegrass/white clover pasture grazed by steers has been shown to be a double normal distribution representing "frequently" and "infrequently" grazed areas. It is not known to what extent a similar double normal distribution of pasture height exists under mixed grazing.

In a 17 week grazing experiment, sward surface height (SSH) was measured daily on a ryegrass/white clover sward, continuously grazed at a mean pasture height of 4.0 cm by nine yearling heifers (CA) or by nine heifers plus 27 ewe hoggets (C + S) on a ratio 1:1 $W^{0.75}$. A companion rotational grazing treatment was involved.

The mean SSH was similar for CA and C+S in both grazing systems (Continuous: 4.27 vs. 4.26 cm; Rotational: 4.87 vs. 4.82 cm). The effect of species mix on sward height distribution was only significant under continuous grazing, where the proportion of the infrequently grazed heights was six times higher in CA than C+S pastures (0.30 vs. 0.05). The mean height of the "frequently" and "infrequently" grazed area was 0.5 cm (12 %) and 1.5 cm (24 %) higher in C+S than on CA pastures, respectively. Although the trends were similar in rotationally grazed treatments, neither the difference in the proportion frequently and infrequently grazed height, nor the mean sward height of these areas significantly diffrered between C+S and CA swards.

We suggest that this increase in 'grazing height' at the same mean SSH in continuously grazed pastures may explain some of the increase in animal performance under mixed grazing. This effect of mixed grazing was less obvious under rotational grazing.

Keywords: Cattle; co-grazing; continuous grazing; double normal distribution; dung patches; frequently grazed; infrequently grazed; pasture height; rotational grazing; and sheep.

INTRODUCTION

Pasture height is considered the best single predictor of both pasture availability and animal performance, especially on intensively managed temperate pastures. It has been increasingly used, as sward surface height to describe the vertical height of the pasture as presented to the grazing animal, or as a sward plate height to provide a height-mass regression (Gibb and Ridout, 1986). The two main reasons for the popular use of sward surface height in describing pasture condition and animal performance are: (1) that grazing animals show more consistent patterns of response to pasture height than other sward parameters under different conditions (Hodgson, 1990), and (2) that it is easy to measure.

Traditionally, pasture height has been described by a sample mean and standard deviation with the assumption of a symmetrical distribution. However, in practice the grazing of pasture by domestic ruminants is patchy and exhibits "frequently" and "infrequently" grazed areas giving a skewed frequency distribution of height measurements. Gibb and Ridout (1986) argue that the assumption of a symmetrical frequency distribution can be potentially misleading, as the frequently and infrequently grazed areas can differ in the vertical distribution of plant parts (Gibb, 1991). They proposed the use of a double normal distribution which they successfully applied to the frequency distribution of pasture height on a ryegrass/white clover pasture grazed by steers. Their later work (Gibb and Ridout, 1988) on swards under five different systems of management, all grazed by steers, further showed that the fitting of a double normal distribution gives a true reflection of the distribution of heights on grazed swards, because it estimates the relative proportion as well as the mean height, of the 'frequently' and 'infrequently' grazed areas.

Mixed grazing studies with sheep and cattle have shown that pasture grazed by sheep and cattle is less patchy, because sheep more readily graze around cattle dung pats than do cattle (Forbes & Hodgson, 1985). The question as to whether this phenomenon would lead to different frequency distribution of height measurements and proportion of frequently and infrequently grazed areas on pastures grazed by cattle and sheep to that grazed by cattle alone has not been formally tested. This paper addresses this question.

MATERIALS AND METHODS

Treatments. Nine heifers (cattle alone:CA) and nine heifers plus 27 ewe hoggets (cattle and sheep: C+S) were continuously grazed on an irrigated ryegrass/white clover pasture during late spring-summer of 1993/94 (15 Nov. to 5 March). Respective companion groups were grazed rotationally on a similar pasture, completing the planned four treatments: two grazing systems (rotational vs. continuous) and two species mix (cattle alone vs. cattle and sheep). The heifers were a mixture of Hereford and Hereford-Angus yearlings (initial liveweight 190 kg), while the sheep were all two-tooth Corriedale ewe hoggets (initial liveweight 45 kg). The co-grazed cattle and sheep were mixed on a 1:1 $LW^{0.75}$ basis.

A total area of 4.42 ha was allocated to each treatment under continuous grazing. 2.95 ha (2/3) was assigned to C+S

and 1.47 (1/3) to CA, and sward height was kept at 4.0 cm by adding or removing extra animals. In the rotationally grazing group, C+S and CA were grazed side by side separated by an electric fence. They were given fresh area daily, CA received one-third of the new area (i.e. half the area given to C+S) though the size was adjusted regularly to achieve the same post-grazing height with C+S. Both CA and C+S animals had access to areas given on the previous two days. The size of the new area provided daily was such that the weekly liveweight change of the rotationally grazed sheep was equal to that of the continuously grazed group (details and liveweight data are reported elsewhere (Kitessa and Nicol, 1995)).

Measurements. Sixty measurements of sward surface height (SSH) were made daily over the 17 week period on the continuously grazed pastures using the HFRO sward stick (Hill Farming Research Organisation, 1986). On eight different occasions, the site of each height measurement was classified as being frequently grazed or infrequently grazed area based on the presence or absence of dung fouling and/or evidence of recent severance of leaves through grazing. On the rotational treatment, 40 measurements of pre- and post-grazing SSH were taken daily.

Data analysis. The test for a double normal frequency distribution of the SSH and the post-grazing height data from continuously and rotationally grazed swards respectively, was made using the computer programme MLP, maximum likelihood programme (Ross, 1987). For each treatment, height data on only every second day was used in fitting the models because the programme had a data limit maximum of 5, 000. The programme provided the fit of a sequence of models to the data in the following order of increasing number of parameters:

(1) single normal distribution ,
(2) double normal distribution with equal proportion and equal variance,
(3) double normal distribution with different proportions but equal variance, and
(4) double normal distribution with different proportions and unequal variance.

With each treatment, the model which first showed a non-significant chi-square test of predicted values with observed values was accepted. The mean, standard deviation, and the proportion of the frequently and infrequently grazed areas were obtained from the MLP output. Using these parameters, predicted values within each distribution of heights were determined by using the statistical NORMDIST function of Microsoft Excel 5.0 (Microsoft Corporation, 1993).

RESULTS

Over the 17 week grazing period, the mean sward height of CA and C+S treatments were 4.27 and 4.26, and 4.87 and 4.82 on continuous and rotational grazing systems, respectively. There was no significant difference between the mean sward heights of the two species mix under either grazing system. As shown in Table 1, there was agreement between the proportion of the sward subjectively classified as being infrequently grazed and that predicted using the maximum likelihood programme. Parameters from the fitted double normal distributions, including the overall mean heights, for each treatment are summarised in Table 2. In each treatment, a double normal distribution better fitted the data than a single normal distribution. All treatments showed equal variances for the mean sward heights of the frequently and infrequently grazed areas, except CA on continuous grazing, which showed unequal variance. In both grazing systems, the mean height of the frequently grazed areas was higher and the proportion of the infrequently grazed areas was lower on the swards grazed by cattle plus sheep than on those grazed by cattle alone (Table 2). However, both contrasts were less marked in rotationally grazed swards.

The frequency distribution of observed and fitted sward heights of continuous grazing treatments are illustrated in Fig. 1. The observed data show a skewed distribution irrespective of the animal species mix. C+S, the less skewed of the two treatments (Fig. 1), still showed a significant lack of fit to a single normal distribution (P>0.001).

TABLE 1: The proportion of swards subjectively classified as infrequently grazed and that predicted using MLP(Maximum Likelihood Programme).

	Subjectively Classified	MLP Predicted	Difference (P<0.05)
CA	0.20	0.17	ns
C+S	0.08	0.05	ns

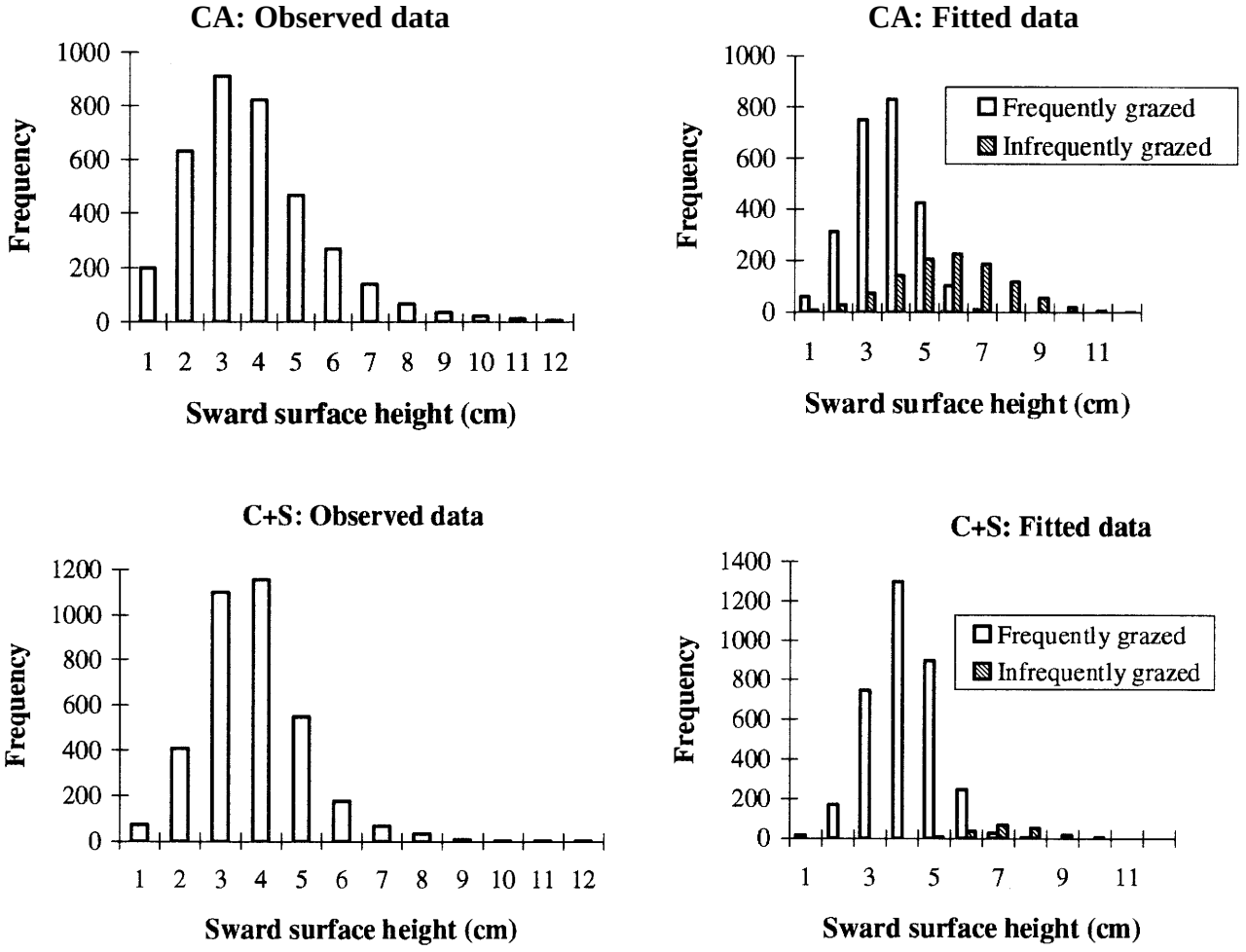
TABLE 2: Parameters of the frequency distribution of sward height on pastures grazed by cattle alone (CA) or cattle plus sheep (C+S) using continuous or rotational grazing.

	CONTINUOUS		ROTATIONAL	
Parameter	**CA**	**C+S**	**CA**	**C+S**
Overall mean (cm)	4.27	4.26	4.87	4.82
s.d.	1.80	1.32	1.96	2.03
Mean height of frequently grazed area (cm)	3.63	4.10	4.09	4.20
s.d.	1.14	1.04	1.08	1.26
Mean height of frequently grazed area (cm)	5.83	7.23	7.46	7.73
s.d.	1.19	1.04	1.08	1.26
Proportion of area infrequently grazed (p)	0.30	0.05	0.22	0.17

DISCUSSION AND CONCLUSIONS

The less “patchiness” of swards continuously co-grazed by cattle and sheep observed by other authors (Nolan and Connolly, 1992) appears to be a consequence of a large reduction in the proportion of areas infrequently grazed (in this case about 80 % reduction: from 30 to 5 % of total area). This would support the supposition of the willingness of sheep to graze around cattle dung pats (Forbes and Hodgson, 1985) with a consequent increase in the percent area utilised which leads to improvement in animal performance (Bennett *et. al.*, 1970, Hamilton, 1976,

FIGURE 1: The frequency distribution of observed and fitted (double normal) pasture heights on swards continuously grazed by cattle alone or cattle plus sheep.



Bowns, 1989). Our results suggest that in addition to improvement in percent utilisation, co-grazing cattle and sheep also increases the mean sward surface height on both the frequently and infrequently grazed areas of the sward. That is, under continuous grazing, at the same overall mean height, cattle grazing with sheep are grazing on a higher sward height than cattle grazed alone, independently of whether they are grazing frequently or infrequently grazed areas. Therefore, the improvement in animal performance reported by various authors on mixed grazing experiments could be partly an outcome of co-grazed cattle and sheep grazing at a higher height.

There are two sets of published work on the frequency distribution of sward height on continuously grazed pastures: Gibb and colleagues work with steers grazed on ryegrass/white clover pastures under different managements (Gibb and Ridout, 1986, 1988; Gibb, 1991), and Wright and Whyte's (1989) report on multiparous cows and calves also grazed on a similar pasture species. Wright and Whyte (1989) subjectively classified the sites of each height measurement as frequently and infrequently grazed area while Gibb and Ridout's and our results were based on estimates obtained from a double normal distribution. However, our observations on data gathered on some occasions during the current experiment show little difference between the proportion of areas subjectively classified as being infrequently grazed and that determined using the MLP programme.

The following sections compare our results to regression lines fitted to data from the reports of other authors (see above). The proportion of the area infrequently grazed by CA lies close to the regression line for this proportion and the mean height of swards grazed by steers, whereas the proportion infrequently grazed by C+S agree more with data from grazing by cows plus calves (Fig. 2). Similarly, although not so conclusively, both the mean height of frequently and infrequently grazed areas of swards grazed by cattle alone appear closer to the respective regression lines of the steer data (Fig. 3) than those heights from swards grazed by cattle plus sheep which lie closer to the regression line of data on cows plus calves (Fig. 4).

Interestingly, the steer data suggest that for a unit increase in the mean height of pasture, the mean height of the infrequently grazed areas increases about three times as much as the increase in the mean height of the frequently grazed areas (Fig. 3). On the other hand, on swards grazed by cows and calves, sward height on both frequently and infrequently grazed areas seemed to increase with the same magnitude, with increasing overall mean height of the sward (Fig. 4).

FIGURE 2: The proportion infrequently grazed on CA and C+S treatments compared to that on swards grazed by cows and calves (Wright & Whyte, 1989), or steers (Gibb & Ridout, 1986, 1988; Gibb, 1991).

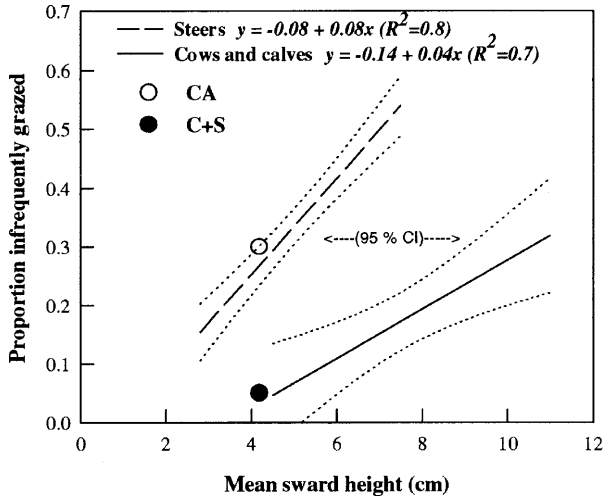
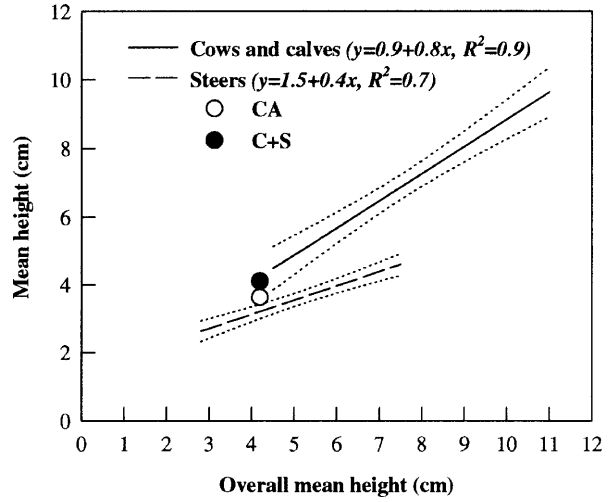


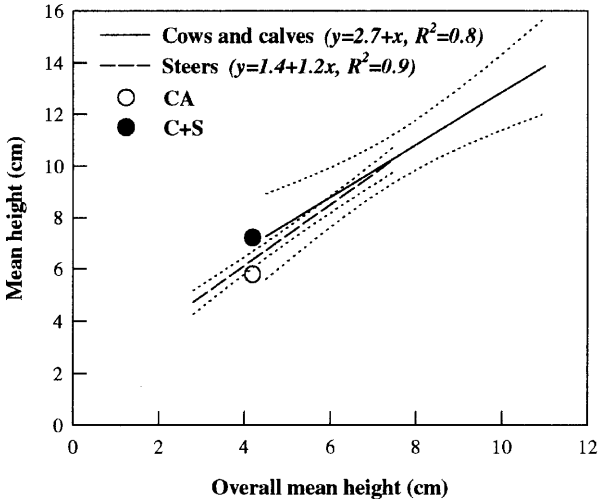
FIGURE 3: The mean height of frequently grazed areas on CA and C+S swards compared to the regression of this height on the mean height of swards grazed by cows and calves Wright & Whyte, 1989), and steers (Gibb & Ridout, 1986, 1988)



This suggests that patchiness of grazed swards can also be reduced by combining different classes of animals of the same species as well as by different species combination. However, whether swards grazed by cows and calves are less patchy than swards grazed by cows alone, as well as the implicit suggestion that swards grazed by cows and calves are of similar patchiness as swards grazed by cattle plus sheep requires validation under the same management. Similarly, further investigation is needed to test if the change in the height of the frequently and infrequently grazed areas with increasing sward height is dependent on animal type or species combination

To summarise, in continuously grazed swards, at the same overall mean height, the mean height of the frequently grazed areas was higher and the proportion of the total area infrequently grazed was lower on swards grazed by cattle plus sheep than those grazed by cattle alone. This may be one

FIGURE 4: The mean height of infrequently grazed areas on CA and C+S swards compared to the regression of this height on the mean height of swards grazed by cows and calves (Wright & Whyte, 1989) and steers (Gibb & Ridout, 1986, 1988).



of the reasons that higher animal performance has been reported from mixed grazing experiments involving sheep and cattle. Other combinations, like cows and calves also seem to produce swards of less patchiness than swards grazed by cattle alone under continuous grazing.

In rotationally grazed swards the frequency distribution of sward height was not affected by species combination. There is no other published report on the frequency distribution of sward height on rotationally grazed pastures. From our results, it appears that there is little difference in patchiness between swards rotationally grazed by cattle alone and cattle plus sheep. It is most likely that patchiness of rotationally grazed swards depends more on the post-grazing height imposed than it does on the species mix.

ACKNOWLEDGMENTS

This project was partially funded by AGMARDT. We thank Dr. Richard Sedcole for helping with data analysis, and Messers Steve Kirsopp and Glenn Judson for helping during field work. The first author would like to thank the New Zealand Vice Chacellors' Committee and trustees of the following scholarships: Syd Bodmin, MacMillan Brown Agricultural Scholarship, Sir Charles Hilgendorf Memorial, and Kathleen Ann Stevens Scholarship.

REFERENCES

Bennett, D, Morely, F.H.W., Clark, K.W. and Dudzinski, M.L. 1970. The effect of grazing cattle and sheep together. *Australian Journal of Experimental Agriculture and Animal Husbandry*, **10:** 696-709.

Bowns, J.E. 1989. Common use: better for cattle, sheep and rangelands. *Utah Science*, **50(2):** 117-123.

Forbes, T. D. A. and Hodgson, J. 1985. The reaction of grazing sheep and cattle to the presence of dung from the same or the other species. *Grass and Forage Science*, **40**: 177-82

Gibb, M. J. 1991. Differences in the vertical distribution of plant material within swards continuously stocked with cattle. *Grass and Forage Science*, **46:** 339-42.

Gibb, M. J. and Ridout, M. S. 1986. The fitting of frequency distributions to height measurements on grazed swards. *Grass and Forage Science,* **41:** 247-49.

Gibb, M. J. and Ridout, M. S. 1988. Application of double normal frequency distributions fitted to measurements of sward height. *Grass and Forage Science,* **43:** 131-36.

Hamilton, D. 1976. Performance of sheep and cattle grazed together in different ratios. *Australian Journal of Experimental Agriculture and Animal Husbandry,* **16:** 5-11.

Hill Farming Research Organisation, 1986. Biennial Report, 1984-1985. pp. 29-30.

Hodgson, J. 1990. Grazing management: science into practice. Longman Scientific and Technical and Wiley and Son, Inc., New York. 203.pp.

Hodgson, J., Arosteguy, J.C., and Forbes, T.D.A. 1985. .Mixed grazing by sheep and cattle: effects on herbage production and utilisation. *XV International Grasslands Congress, August 24-31, 1985, Kyoto: pp.*1108-1110.

Kitessa, S. M. and Nicol, A. M. 1995. Co-grazing of sheep and cattle using rotational or continuous grazing. IV International Symposium on the Nutrition of Herbivores. Printed in: *Annales de Zootechnie,* **44** (Suppl. 1): 131.

Microsoft Corporation (1993). Microsoft Excel 5.0. Users' Guide pp.601.

Nolan, T. and Connolly, J. 1992. Efficiency of utilisation of grazed pastures for livestock production through synchronisation of food supply and food requirements. *Proceedings of global appraisal of livestock farming systems and study of their organisation levels: concepts, methodology and results, 7 July, 1990, Toulouse, France:* pp.323-331.

Ross, G. J. S. 1987. Maximum likelihood programme. MLP 3.08. Lawes Agricultural Trust. Rothamsted Station.

Wright, I. A. and Whyte, T. K. 1989. Effect of sward surface height on the performance of continuously stocked spring calving beef cows and their calves. *Grass and Forage Science,* **44:** 259-66.