EFFECT OF CONTINUOUS STOCKING OF BREEDING EWES AT DIFFERENT SWARD SURFACE HEIGHTS DURING THE LATE SUMMER-AUTUMN ON HERBAGE INTAKE AND PRODUCTIVITY

A thesis presented in partial fulfilment
of the requirements for the degree of

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ABSTRACT

Panggabean, A.U. 1995: Effect of continuous stocking of breeding ewes at different sward surface heights during the late summer-autumn on herbage intake and productivity. MAgrSc thesis. Massey University, Palmerston North, New Zealand. 66 pp.

Continuous stocking management is preferred by many New Zealand sheep farmers during the late summer-autumn period. At present, there are no guidelines available to farmers that define the optimum sward conditions for continuous stocking management of ewes leading up to, and during, the mating period. Three different nominal sward surface heights (SSH) (2, 4, and 6 cm) replicated twice were used for a trial with 14 mixed age breeding ewes per treatment (n=84 ewes) continuously stocked from February to April 1994. The pastures consisted of predominantly 10-year old ryegrass (*Lolium perenne*), white clover (*Trifolium repens*) and browntop (*Agrostis capillaris*). Sward heights were measured weekly throughout the trial. Herbage intakes by the ewes were determined indirectly from faecal output using chromic oxide controlled release capsules and *in vitro* digestibility of digesta samples obtained from oesophageal-fistulated sheep run with the ewes.

The average actual sward surface heights for the 2, 4, and 6 cm SSH treatments were 2.7 *vs* 4.3 *vs* 6.1 cm (± 0.05 cm (SEM), P<0.001). The pasture characteristics in terms of herbage mass, dead matter content and organic matter digestibility (OMD) for the 2, 4, and 6 cm SSH treatments were: 2723 *vs* 3880 *vs* 4337 (± 204 kg DM/ha, P<0.05); 69.74 *vs* 64.62 *vs* 51.37 (± 2.78%, P<0.05); 66.52 ± 0.85 *vs* 60.29 ± 0.90 *vs* 69.56 ± 0.84% (P<0.01). The daily liveweight gain, condition score, wool growth rate and mean fibre diameter for ewes grazing the 2, 4, and 6 cm SSH treatments were: 103 *vs* 122 *vs* 195 (± 15 g/day, P<0.05); 2.89 *vs* 3.05 *vs* 3.23 (± 0.06 condition score units, P<0.1); 1.30 *vs* 1.26 *vs* 1.41 (± 0.03 mg/cm^2/day, P<0.1); 43.01 *vs* 44.07 *vs* 44.48 (± 0.35 microns, P>0.1).

The results suggest that swards of at least at 6 cm height are required to support adequate liveweight gain and condition score of breeding ewes in the period prior to and during mating. The accumulation of weed and dead material appear to be the major problems limiting intake and ewe performance.

Keywords Continuous stocking; late summer-autumn; sward height; breeding ewes

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This thesis is dedicated to the memory of my late father who encouraged me to undertake further study. He has played a significant role in my achievement so far.

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LIST OF ABBREVIATIONS

%	percentage
cm	centimetre
cm^2	square centimetre
Cr	chromium
d	day
DM	dry matter
DMD	dry matter digestibility
DMI	dry matter intake
DOMD	organic matter digestibility of dry matter
DOMI	digestible organic matter intake
et al.	and others
g	gram
h	hour
ha	hectare
i.e.	that is to say
kg	kilogram
LW	liveweight
MEI	metabolizable energy intake
mg	milligram
N	nitrogen
$^{o}\ ^{1}$ S	degree minute south
°C	degree Celsius
OMD	organic matter digestibility
OMI	organic matter intake
S.E.M.	standard error mean
vs	versus

CHAPTER ONE

INTRODUCTION

PREAMBLE

This study addresses the effect of continuously stocking breeding ewes, on pastures of different sward surface heights during the late summer-autumn, on their herbage intake and productivity. The study was conducted because most sward surface height guidelines available for New Zealand farmers, particularly for the period prior to and during mating in the autumn, are based on overseas research. Chapter One reviews the literature on this subject and develops a rationale for the experimental work that follows (Chapter Two).

PASTORAL SHEEP PRODUCTION SYSTEMS

Sheep farming in New Zealand is a pastoral-based system in which farmers depend entirely on pastures as the feed resource for livestock. It is a low cost/low input system of livestock production whereby permanent pastures are utilized by grazing animals. Within this type of farming, grazing animals obtain ninety percent of their total nutrient requirements from pasture (Hodgson 1990). A number of factors can influence pasture productivity and hence the level of animal production that can be achieved in a pasture-based sheep farming system.

Seasonal Effects

Pasture production follows a highly seasonal pattern characterized by peak herbage growth rates in spring, frequently creating surpluses, and then lower growth rates in winter, creating feed deficits (Figure 1). Where terrain permits, spring herbage surpluses are often conserved as hay or silage and are made available to livestock during periods of low herbage growth rates. Herbage growth is influenced by environmental factors such as temperature, rainfall, wind, evaporation rate and sunlight. Adequate soil temperature and moisture are required to support high herbage growth rates such as occurs in spring pastures.

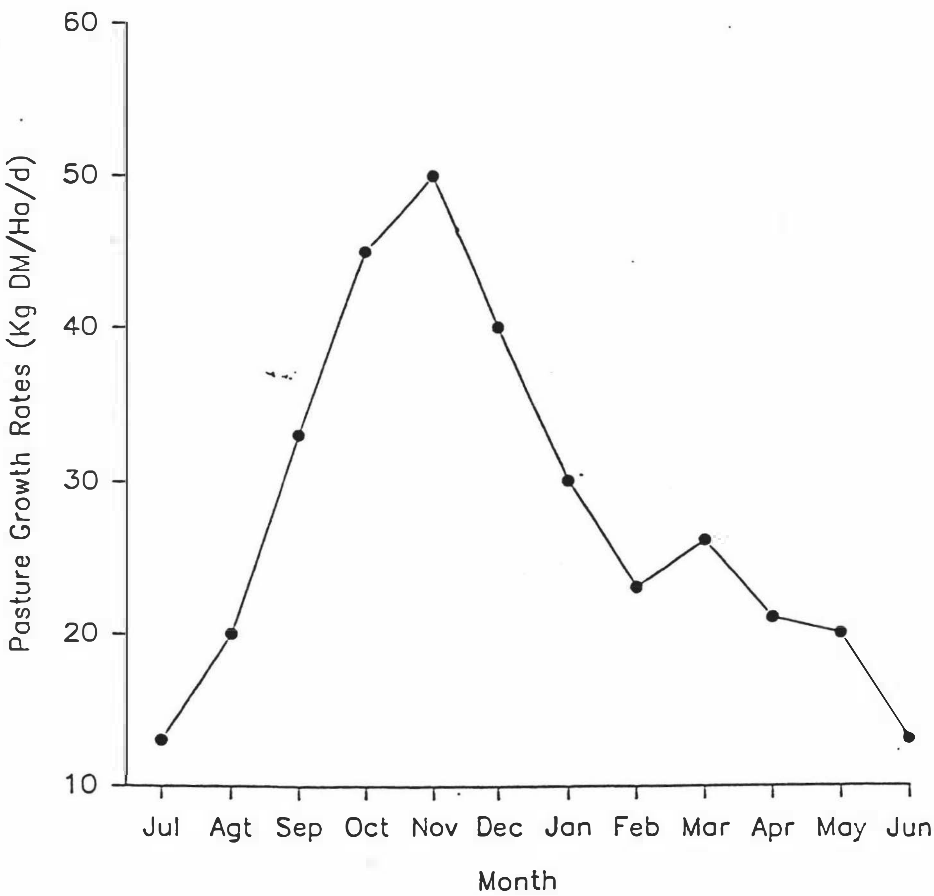

Figure 1 Seasonal distribution of herbage growth rates in kg DM/ha/day (1981-1987) at Keeble Farm, Massey University, Palmerston North, New Zealand (latitude 41° 10[1]S) (Hawkins *et al.* 1989).

Low herbage growth rates during winter are associated with low ambient and soil temperatures (Korte *et al.* 1987). The colder the winter and the higher latitude or altitude, the lower are winter herbage growth rates and often the greater will be the spring flush of growth. Different species have different responses to temperature and season. For example, annual ryegrass (*Lolium multiflorum*) shows higher winter and early spring growth rates than perennial ryegrass (*Lolium perenne*) while subterranean clover (*Trifolium subterraneum*) has higher winter growth rates than white clover (*Trifolium repens*). In general, grasses have greater production than clovers during the winter months (Suckling 1960).

High temperatures and lack of moisture, such as are experienced in summer drought conditions, can also reduce pasture production. Coop (1986a) concluded that high temperatures, high rainfall and low exposure to wind are the major determinant factors that will support high herbage growth rates.

Herbage Composition Within The Sward

Herbage composition, in terms of the proportion of grasses, legumes, weeds, and dead material, will affect the performance of grazing animals. For example, at low pasture allowances, lamb liveweight gains were 150-200 g/day higher on clover-dominant pastures (60-80% clover content) than on ryegrass dominant pastures (0-25% clover content) (Rattray *et al.* 1983). This also occurred for ewe liveweight gain (a difference of 50-100 g/day) and ovulation rate and was most likely associated with the higher digestibility and feeding value of clover.

Within species, differences in plant structure such as the length of tillers, height and spatial distribution of leaf will also determine the accessibility of pasture for livestock. For instance, at low herbage allowances, ewes and lambs grazing prairie grass (*Bromus willdenowii*) have higher production than those grazing perennial ryegrass (*Lolium perenne*). This is attributed to the distribution of leaf material within the sward. Thus prairie grass has evenly distributed leaf, allowing sheep to have easier access to harvest this grass. On the other hand, the distribution of leaf material in ryegrass is at the low horizon level, resulting in difficulties in the harvesting process for sheep (Frazer 1982; L'Huiller *et al.* 1984). Thus, herbage composition and plant structure affect the ability of the grazing animals to harvest herbage from swards.

It is well recognized that the more mature the plant, the less desirable it is to livestock (Hodgson 1990). This is attributed to herbage digestibility, mature plants being less digestible than younger plants. Plant digestibility is also determined by plant physical structure (i.e. ratio of cell wall to cell contents). The ratio of cell wall to cell contents is higher in grasses than in legumes, leading to a lower rate of digestion in grasses. In addition, grasses have a high stem to leaf ratio which will also influence the rate of digestion, because the higher this ratio the lower rate of digestion (McDonald *et al.* 1981). Conversely, for legumes the lower ratio of cell wall to cell contents and the lower ratio of stem to leaf result in a higher rate of digestion and fractional ruminal outflow rate, and ultimately a higher animal intake than for grasses.

Stocking Rate

Stocking rate refers to the number of animals (or the total liveweight of animal) per unit area in a given period of time (head/ha or kg LW/ha). In pastoral sheep farming systems, it is one of the most important animal factors governing pasture utilization and animal production per unit area.

An increase in stocking rate will increase the defoliation of individual tillers within the sward, resulting in a decrease in herbage intake. High stocking rates, under either continuous stocking or rotational grazing, will reduce herbage growth rates as pastures become overgrazed (Campbell 1969; Carter and Day 1970). Digestibility of the diet consumed by animals may also be low due to the limited amount of green herbage. In addition, high stocking rates will cause treading damage and soil compaction. However, these factors are offset to some extent by the increased recycling of dung and urine into plant nutrients (Hodgson 1990).

Low stocking rates result in underutilized pastures leading to an increased proportion of stem material and ultimately a high senescence rate. Under this scenario, herbage growth rates will start to decline.

Stocking rate appears to be a key determinant of the productivity and profitability of sheep farms in New Zealand. However, the expression of stocking rate as the number of animals per unit area does not accurately reflect the effective stocking rate for the farm. The size, type of animal and level of production might all contribute to misinterpretation of this term. Holmes and Parker (1992) suggested that stocking rate can be mostly effectively expressed in terms of herbage utilization (herbage utilization = total herbage eaten per hectare/total herbage grown per hectare), preferably calculated for the entire year.

The choice of stocking rate must take into consideration other farm factors. A high stocking rate option is often preferred by farmers who plan to accumulate capital whereas a low stocking rate is a lower risk option and is likely to be preferred by well-established farmers (Holmes and Parker 1992).

THE CONCEPT OF HERBAGE AVAILABILITY MEASUREMENTS UNDER PASTORAL GRAZING SYSTEMS

The determination of herbage availability is an important aid in pasture management and feed budgeting as it defines pasture conditions which in turn can be used to establish relationships between sward conditions and animal performance (liveweight change, ovulation rate, wool production, lamb production). Terms to describe herbage availability, such as herbage allowance, herbage mass and sward surface height (SSH), have been well developed and used extensively in both research and field practice.

Herbage Mass and Herbage Allowance

Herbage mass is a term used to define herbage availability within a particular area. It describes the amount of above-ground parts of pasture plants, including live and dead herbage, and is expressed as kg DM/ha at any given time (Bircham and Hodgson 1981; Poppi *et al.* 1987). A pre- and post-grazing herbage mass are usually defined to distinguish the amount of herbage initially present and remaining (after grazing) in the pasture, respectively. The pre-grazing herbage mass refers to the amount of herbage available before grazing (kg DM/ha on the day of measurement) while the post-grazing herbage mass represents the residual dry matter which is not consumed by the animals and therefore remains on the pasture. Post-grazing herbage mass reflects the intensity or severity of grazing, with a low post-grazing mass indicating a high intensity of herbage defoliation, and a high post-grazing mass reflecting a lax grazing. The difference between pre- and post-grazing herbage mass divided by the total number of grazing animals and total grazing days is usually used to express daily herbage intake per animal (kg DM/head/day) (Meijs 1981). Measurement of intake using this formula is only appropriate in rotational grazing systems with short grazing periods (1-3 days) and high grazing pressures, so that herbage accumulation can be disregarded. It is obviously unsuitable to continuous stocking systems as herbage growth during the grazing period will bias the estimation of intake.

Change in herbage mass is almost always used to assess herbage growth under New Zealand pastoral systems and the actual herbage mass at a point in time (average pasture cover measured as kg DM/ha) measures the total amount of herbage available for the livestock within a particular area (Sumner and Rattray 1980; Rattray and Clark 1984). However its use as predictor of animal performance is limited by variation in sward composition, and in the ratios of leaf to stem, and green to dead material (Korte *et al.* 1987).

Herbage allowance refers to the amount of herbage allocated to livestock. It is calculated by dividing pre-grazing herbage mass measured to ground level by the number of grazing animals per unit area (Rattray and Jagusch 1978; Poppi *et* *al.* 1987; Hodgson 1990). It is expressed as kg DM/head/day or kg DM/kg liveweight/day.

Herbage allowance can be used to assess how much herbage should be offered to grazing animals to meet their nutrient requirements. As animals can harvest only a proportion of the available pasture, herbage allowance is always greater than intake reflecting that there is ungrazed herbage left on the sward. The post-grazing herbage mass or residual herbage mass together with a knowledge of the pre-grazing herbage mass give an indication of herbage utilization. Herbage allowance appears to be the most important factor which is responsible for the differences in animal intake and performance (Rattray and Jagusch 1978; Jagusch *et al.* 1979a).

Sward Surface Height (SSH)

An alternative to herbage mass and allowance is sward surface height (SSH). SSH is simply defined as the average height of the upper surface of the leaf canopy measured on an undisturbed sward (Hodgson 1990). SSH can be used as a guide for grazing control, particularly in continuously stocked systems where animals respond more consistently to variations in sward height than to variations in herbage mass (Hodgson 1990). In addition, sward height is easily measured. Thus, SSH is a useful indicator of the relationship between sward conditions and animal performance and its measurements can be applied to controlling sward state, herbage intake and animal performance (Maxwell 1985; Hodgson 1990; Morris 1993).

The use of SSH in grazing management guidelines has been well developed in the United Kingdom (UK). In the late summer-autumn period, when herbage growth rates are beginning to decline, ewes tend to graze to low levels and encounter the dead and decaying herbage material at the base of the sward. A target height of 3-6 cm under continuously stocked UK systems has been recommended to maintain body condition (Table 1) (Hodgson 1990). This is in agreement with the study of Penning *et al.* (1991) who found that, during the autumn period, swards maintained at 3-6 cm were densely tillered, uniform in height, and therefore could be expected to supply feed to meet animal requirements. Moreover, a sward of 9-12 cm SSH will contain a considerable proportion of dead stems and hence a higher proportion of dead material.

Table 1 Seasonal guidelines for sward surface height (cm) under continuously stocked systems of grazing management.

<table>
<tr><th>MONTH</th><th>SHEEP</th><th>CATTLE</th></tr>
<tr><td>Winter</td><td>3-4</td><td rowspan="2">5-8</td></tr>
<tr><td>Spring</td><td>3-5</td></tr>
<tr><td>Late spring</td><td rowspan="2">4-6</td><td>6-8</td></tr>
<tr><td>Summer</td><td rowspan="4">7-10</td></tr>
<tr><td>Autumn</td><td>6-8
(dry ewes 3-4)</td></tr>
<tr><td>Late autumn</td><td>4-6</td></tr>
<tr><td>Winter</td><td>graze down to 3-4</td></tr>
</table>

Source: Hodgson *et al.* (1990).

Therefore, under continuously stocked grazing systems, SSH should be maintained within the range of 3-6 cm and any increase in SSH above this level will not improve animal performance.

Under New Zealand pastoral systems, however, the use of SSH in grazing management guidelines has been limited. Parker and McCutcheon (1992) established SSH guidelines for single- and twin-rearing ewes during lactation under continuously stocked grazing systems. Similar guidelines for winter- and spring-lambing ewes during late pregnancy and for winter-lambing ewes during lactation have also been established (Morris *et al.* 1993a; Morris *et al.* 1993b; Morris *et al.* 1994). Corresponding guidelines for the summer-autumn period (the period prior to and during mating) are not available, other than via the preliminary report of Burnham *et al.* (1994).

ASSESSMENT OF HERBAGE ALLOWANCE

Pastoral-based farming systems, in which pasture is the sole feed resource, require methods of measuring pasture production and of assessing the amount of herbage available to livestock. Assessment of herbage can be through either destructive or non-destructive methods. Destructive methods refer to the sward cutting technique where herbage is cut and removed from a defined area. The herbage is dried and weighed to obtain a dry matter content and then expressed as herbage mass (kg dry matter) within a particular area. However, its application is influenced by climatic conditions, and wet conditions often preclude cutting. It also tends to damage the sward, and is laborious and time consuming.

Non-destructive methods of assessing herbage production have been developed to alleviate the abovementioned problems. They mostly focus on measuring sward height and then establishing a relationship between height and herbage mass. There are a number of devices use to measure sward height and herbage mass.

Single Probe Capacitance Meter

This device uses a single rod probe and an electronic system that accumulates readings from a number of sampling sites within a pasture plot. It was firstly introduced by Campbell *et al.* (1962) and then the improved capacitance meter was released by Vickery *et al.* (1980). The latter instrument takes advantage of an integrated circuit technology to improve stability and ease of use of the instrument. In addition, it uses an earth spike which is mainly responsive to the area of foliage. However, it is less sensitive to dried pasture because dry pasture resistance is so high that an electrical contact no longer exists within the probe. Thomson (1983) found that capacitance meter readings were significantly correlated with fresh weight of pasture and least associated with dead pasture content. As the instrument responds largely to leaf surface area, it requires re-calibration to accommodate large changes in vegetation type.

Calibration can be conducted with a double sampling technique which develops the relationship between pasture mass or height and the measurement method (i.e. readings from the capacitance meter). The technique measures the height and weight of herbage within quadrats then readings are taken off the derived curve (Black *et al.* 1969). The technique will overcome the problems of having large numbers of samples and will give more precise herbage estimates than height measurement alone.

Ellinbank Pasture Meter (EPM)

The Ellinbank Pasture Meter (EPM) or rising plate meter is designed with a moveable flat-plate and a rod scale. The plate is free to slide up and down on the rod. When placed on the ground, the herbage above ground level will push the plate upwards and the height to which the plate is pushed is the height of herbage being measured.

The rising plate meter is known to be more reliable and consistent than visual appraisal (Holmes 1974) and it has been shown to be useful on swards of perennial ryegrass-white clover in winter and early spring (Earle and McGowan 1979). It requires less training or mental effort by the operator and has advantages over the capacitance meter as it is easier and faster and does not suffer calibration drift due to temperature or humidity changes (Earle and McGowan 1979).

A study conducted to compare a rising plate meter and a single capacitance meter calibrated on perennial ryegrass swards over the spring and summer period resulted in a more accurate estimation of herbage mass using the EPM due to the lower residual standard deviations and the more stable relationships between the EPM and herbage mass over the spring period (Michell and Large 1983). However, neither meter was able to give accurate results on swards containing large amounts of dead material. Furthermore, the calibration of the EPM is influenced by the changes in moisture content and type of the pasture as well as the effect of sward compaction through trampling and lodging (Jones and Haydock

1970). It is also dependent on botanical composition and therefore it is not ideally suited for comparing herbage production in swards of contrasting botanical composition, or where there is a marked variability in composition (Earle and McGowan 1979).

If a more accurate estimation is the main objective in assessing herbage production, it is suggested that a combination of the EPM or capacitance meter with visual assessment be used (Holmes 1974; Thomson 1983) the latter focusing on the mean dead matter content of the sward.

Hill Farming Research Organization (HFRO) Sward Stick

This method of measuring sward surface height was developed by Barthram (1986). The stick is placed vertically in the sward and the 2x1 cm plastic window is lowered until it touches any part of a green leaf. The height, as indicated at the pointer, is recorded. Measurements of 40 to 50 points should be taken randomly across grazed and ungrazed areas. The meter readings are recorded to the nearest half-centimetre and the average height is obtained by dividing the total reading by the number of points (Hodgson 1990). The more meter readings taken, the more reliable is the estimate of sward height.

Contacts with stem or seed heads as well as measurements on atypical sites (bare patches, troughs, under trees) should be avoided (Hodgson *et al.* 1986). Barthram (1986) reported a mean standard error of 5% or within-plot coefficient of variation of 30% when the sward stick is used. He also recommended that the sward stick can be used to assess herbage mass with appropriate double sampling techniques.

The double sampling technique is used to calibrate the pasture height to herbage mass following the linear regression model, that is:

$$y = f(x) = \alpha + \beta x.$$

where:

y	= mean yield of herbage organic matter per unit area (kg/ha)
x	= meter readings taken with the pasture yield estimator (cm)
α and β	= unknown numerical constants estimated by α and β.

The accuracy of the technique depends on the closeness of relationship between x and y, that is sward height and herbage mass, respectively, the number of paired observations and the number of additional observations of x (Black *et al.* 1969).

O'Sullivan *et al.* (1987) conducted a trial to investigate the relationship between herbage mass and pasture height using three methods of measuring pasture height (actual height and extended height using ruler, and estimated height using a rising disc instrument).

All three methods gave similar curvilinear relationships. They found that for 3 quadrats, 10 extra height measurements will reduce the mean standard deviation (SD) from 11.6% to 7.1%, and for 6 quadrats it will reduce the mean SD from 8.3% to 5.8%. They recommended that the double sampling technique can provide more precise estimates of herbage mass than a single measurement. In addition, this method will also reduce the workload without reducing the accuracy of the estimation, primarily because of the reduced number of samples needed to estimate herbage mass. It is important that regular and frequent calibrations are made to minimize bias or error (Meijs *et al.* 1982).

METHODS OF CONTROLLING HERBAGE ALLOWANCE

Herbage allowance and sward surface height can be controlled through different grazing systems. A decision on an appropriate grazing system is important so as to ensure the balance between sufficient feed supply for the livestock and the maintenance of good sward conditions. Different grazing systems will therefore have different impacts on sward conditions, and hence on animal intake and performance.

Continuous stocking and rotational grazing are the two grazing systems commonly used by New Zealand sheep farmers.

Continuous Stocking Systems

Continuous stocking or set-stocking refers to the presence of animals within a particular area where they have continuous unrestricted access to the grazing area for relatively long periods (several weeks or the whole grazing season) (Hodgson 1990). This system tends to encourage the development of a dense sward and the maintenance of clover in the sward. It usually exists in extensive conditions and especially on New Zealand hill country farms with minimal subdivision and relatively low stocking rates. Sward surface height needs to be maintained at an appropriate level to ensure sufficient pasture supply to meet animal demand. A high SSH will lead to underutilization of pasture and therefore a reduction in the nutritive value of the pasture. On the other hand, a lower SSH tends to cause erosion of soil, and livestock are likely to be undernourished (Holmes 1980).

Recommendations of optimum sward height under continuously stocked systems must consider factors such as physiological state and the productive potential of the animals together with seasonal variation in herbage growth rates.

Continuous stocking is likely to apply in periods of herbage surplus or in the main pasture growth season and during periods of high animal intake such as early lactation and the pre-mating period (Sheath *et al.* 1987). Management of herbage surpluses will depend on the amount of herbage, degree of feed deficits (e.g. summer and/or winter-early spring) and the time of pasture recovery (Sheath *et al.* 1984). This form of management is well suited to summer-wet areas where land is uniformly subdivided and grazing of different stock classes is well integrated (Sheath *et al.* 1984). British researchers have shown that, under continuous stocking systems, net herbage production and lamb output per hectare are maximized at a herbage mass of 1200-1500 kg OM/ha (3-5 cm sward height) (Hodgson and Maxwell 1984). Penning *et al.* (1991) recommended the range of 3-6 cm as, within this range, a dense leafy sward structure is maintained, resulting in optimum lamb growth rates and ewe liveweight gains without deterioration in the sward canopy. These authors also found that taller swards (9-12 cm) could not improve sheep performance because sward structures started to decline. Recommendations for the autumn period follow a similar pattern where sward height should be maintained around 6 cm and areas should be grazed tightly, if necessary, to reduce sward height to 3-4 cm before winter.

Under New Zealand pastoral systems, continuous stocking is mostly applied during the period from lambing to weaning (Vartha and Hoglund 1983; Bircham 1984). Continuous stocking during this spring-summer period will maintain high tiller densities and support more stable pasture performance, particularly where there is soil moisture stress (Clark and Lambert 1982). Particular attention should focus on the level of herbage mass before and after lambing, and hence herbage allowance for lactating ewes, as it will be reflected in the ewe and lamb performance at weaning (Smeaton and Rattray 1984). It is recommended to have a herbage mass of 1000 kg DM/ha (3-4 cm SSH) or above at the start of lambing. During the winter period, swards maintained at 2 cm height under continuous stocking can support herbage intake of winter- and spring-lambing ewes in good body condition (2.5-3.0) but would be detrimental for ewes in poor condition (Morris *et al.* 1993a).

Low stocking rates under this system are likely to be important as they will allow a high rate of gross photosynthesis but might also cause high rates of decay of dry matter (Parsons *et al.* 1983). This is in agreement with Hodgson (1990) who found that low stocking rates will increase the losses to senescence even though net herbage production and growth rate increase. This increase in maturity of herbage and the associated accumulation of dead material will lead to a decrease in herbage digestibility and therefore limit the animal intake and performance. On the other hand, an increase in stocking rate will increase the frequency of defoliation of individual tillers within the sward. Treading damage and soil compaction at high stocking rates will also depress the rate of herbage growth.

Rotational Grazing Systems

Under this type of grazing system, pastures are divided into several paddocks and livestock are moved in a regular sequence around the paddocks. Consequently, the rotation cycle, grazing and rest period of the paddocks become important as they will determine pasture conditions. Rotational grazing systems tend to develop more open swards and are therefore sensitive to weed infestation and treading damage. This system is also less suitable for the maintenance in the sward of a high proportion of white clover (Holmes 1980).

The grazing period within a paddock will determine both animal and pasture performance. Jagusch *et al.* (1979a) noted that a longer grazing period will enable the sheep to have access to larger areas of re-growth and, consequently, they will grow faster. However, if it is overdone, pasture ahead in the rotation will often become rank and dead material will accumulate. It is therefore important to establish monitoring and control procedures to avoid over-grazing and the accumulation of dead material.

Rotational grazing is commonly practised during the winter months when herbage growth rates are at their lowest. It is used as a rationing tool to ensure that livestock are rationed and excess pasture accumulates for the lambing period.

During periods of herbage surpluses, a fast rotation length of between 15-25 days, but dependent on herbage growth rates, is desirable. A target herbage mass of 1500-2200 kg DM/ha is an attractive management option under unreliable climatic conditions as it offers greater flexibility to judge and manipulate grazing pressure (Sheath *et al.* 1984). In the winter period, typically 60-100 day grazing intervals are recommended (Smeaton and Rattray 1984). Most management recommendations for rotational grazing systems are stated in terms of herbage mass rather than pasture height variables such as SSH.

Comparing both systems is rather difficult because of the complex interaction between plants and animals, as well as long term effects on pasture, particularly botanical composition.

Rotational grazing systems are superior to continuous grazing systems in that they allow better control of sheep intake and hence the opportunity to save pasture, particularly for the lambing period. On the other hand, continuous grazing systems have the advantage of maintaining high pasture utilization rates and hence pasture quality is maintained. However, Coop (1986b) noted that the total rate of herbage production in both systems is similar. It seems likely that the ideal grazing management for a sheep farm should have a combination of both systems. Factors such as seasonal herbage growth rates, pre-grazing herbage dry matter levels and stocking rates are major determinant factors to be considered by farmers rather than constant grazing management systems.

HERBAGE ALLOWANCE, HERBAGE INTAKE AND ANIMAL PERFORMANCE

As stated previously, herbage intake is closely related to pasture allocation (i.e. herbage mass, herbage allowance, pre-grazing herbage mass and post-grazing herbage mass). In general terms, animal performance will increase in diminishing terms as herbage allowance increases (Jagusch and Smith 1982; Rattray *et al.* 1982; Rattray *et al.* 1983; Rattray and Clark 1984; Hawker *et al.* 1985). This makes it possible to control animal intake and performance by means of rationing pasture allocated to animals. Poppi *et al.* (1987) stated that herbage intake in sheep is determined by nutritional and non-nutritional factors.

The non-nutritional factors refer to the ability of the animal to harvest pasture through grazing behaviour (grazing time, bite size, biting rate). They appear to be particularly important in situations of low herbage allowance where animals have difficulties in harvesting pasture which therefore limits intake, or when they are forced to graze to a low herbage mass resulting in an increase in intake of dead material and concurrent decrease in M/D value of the diet (Rattray *et al.* 1987). M/D value is the amount in megajoules (MJ) of metabolizable energy (ME) per kilogram of dry matter given at the maintenance level of feeding (CSIRO 1990). Thus, pasture attributes in terms of structure and composition appear to be major determinants of non-nutritional factors influencing intake.

The nutritional factors deal with processes in the digestive tract and are influenced by sward digestibility, rumen fill and other metabolic factors. These factors appear to control herbage intake at higher herbage allowances and post grazing herbage masses. Digestibility is the major nutritional factor influencing intake as it expresses the proportion of feed energy value (M/D value of the herbage).

Lamb Performance

Lamb liveweight gain is mainly influenced by feeding level and milk production of the ewes from parturition to weaning. It increases proportionally with increases in ewe feeding level reaching a maximum at a herbage allowance of 8 kg DM/ewe/day. It is also influenced by birth and rearing rank, and sex of the lamb (Rattray *et al.* 1982).

Early lactation normally commences in late winter or early spring and coincides with low herbage growth rates and consequent reduction in herbage allowance. Ewe liveweight loss will increase and lamb growth rates reduce when sward height declines below 3-4 cm (Milne *et al.* 1981). It is recommended to have swards at 4 cm height as soon as the spring period commences to maintain ewe milk production.

Under U.K. grazing systems, supplementation is sometimes offered to lactating ewes to avoid reduction in both ewe and lamb performance. However, supplementation for lactating ewes is not commonly applied under New Zealand grazing systems. Instead, maintenance of milk production during the early period of lactation is normally achieved through mobilization of maternal body tissues, particularly when sward height is low (i.e. below 3.5 cm) (Parker and McCutcheon 1992). Ewe liveweight and body condition may reduce as a consequence of the dam buffering lamb production.

In the later stages of lactation, i.e. mid and late lactation, insufficient feed supply to the ewes due to a decline in herbage growth rates may further reduce milk supply and cause a subsequent reduction in lamb growth rates. However, lamb performance is likely to improve or at least be maintained as the lambs start to ingest herbage, i.e. 3-4 weeks after parturition (Penning *et al.* 1986). Competition for herbage between ewes and lambs is also likely to occur. Maintaining swards at an appropriate height becomes imperative to support good lamb performance prior to weaning. Optimum lamb growth rates can be achieved at SSH greater than 4 cm in mid and late lactation (Maxwell 1985; Parker and McCutcheon 1992).

In the post-weaning period, when maternal influence is removed, herbage allowance becomes more important to sustain lamb performance. High liveweight gains in weaned lambs can be achieved through daily intakes of 1 kg DM of ryegrass and white clover herbage (Jagusch *et al.* 1979b). However, greater liveweight gains are achieved at higher feed levels (3 *vs* 1 kg DM/head/day) on clover- compared to grass-dominant pastures. At these feeding levels there is also a pronounced increase in wool growth rate (Thompson *et al.* 1981). There have been few studies on the effect of SSH on post-weaning lamb liveweight gain.

Hoggets

Hoggets (yearling sheep) are still in the growing phase and have not reached their mature weight and size. They have a higher metabolic rate and maintenance requirements for body tissues than breeding ewes. Therefore, they are extremely sensitive to herbage allowance and require sufficient feed supply to attain their growth potential. The effects of herbage allowance on hogget performance (i.e. liveweight gain and wool growth) have been reported extensively.

Liveweight gain appears to be a major factor determining hogget productive performance. Insufficient feed supply, such as is experienced in winter when herbage growth rates and herbage allowances are low, retards liveweight gain which in turn will delay the onset of puberty. A low herbage mass of 1000-2000 kg DM/ha in early spring may reduce hogget intake and hence liveweight gain, and this is mainly attributed to the increased difficulty in harvesting short swards (Thompson 1986).

Hawkins (1993) found that intake and liveweight change were depressed by an increasing proportion of dead material in the diet. He concluded that better performance can be achieved when hoggets are offered high quality pastures (high organic matter digestibility and low dead matter content) as this will lead to a greater accessibility to green herbage.

With respect to wool growth responses, an increase in herbage allowance will increase wool growth and fibre diameter in a curvilinear pattern. It is interesting to note that there was no reference to hogget performance in relation to sward surface height in the literature.

Breeding Ewes

There has been a lot of interest in highlighting the relationship between herbage allowance and, to a lesser extent, sward surface height, and ewe performance. This research emphasizes productivity in terms of liveweight gain, ovulation rate, and lactation.

Herbage availability for breeding ewes is usually concerned with maintaining or improving liveweight and body condition, which in turn are expected to result in high reproductive performance.

Liveweight gain and ovulation rate

Ewe liveweight gain will increase with an increase in herbage allowance, depending on ewe liveweight and body condition at the commencement of feeding.

At the same herbage allowance, lighter and thinner ewes gain more or lose less weight than heavier and fatter ewes. The different responses are attributed to the high energy value of liveweight gain and high maintenance requirements of heavier ewes causing lower liveweight gains than their counterparts (Rattray 1986).

It has also been observed that, at the same herbage allowance, an increase in pre-grazing herbage mass may increase ewe intake and liveweight gain (Rattray and Clark 1984). This is associated mainly with the ease of harvesting and stocking rate. Low pre-grazing herbage mass (short pasture) may cause difficulties in harvesting herbage or alternatively ewes may be forced to ingest a high proportion of dead material which accumulates at the base of the sward horizon. Consequently M/D value of the diet is reduced. A high stocking rate results in increased competition within the flock, limits access to high herbage allowance and therefore reduces intake and liveweight gain. Ewe intake and liveweight gain will apparently decline when pre-grazing herbage mass reduces below 2000 kg DM/ha (Rattray and Clark 1984).

As mentioned previously, there are different responses between fat and light ewes to herbage allowance. This has wide practical application particularly in the weaning to mating period, when a good body condition of breeding ewes is crucial to achieve high reproductive performance. Ideally, farmers like to flush ewes during this period to improve body condition score of ewes at mating, resulting in an increase in ovulation rates and ultimately leading to a higher lambing percentage (Coop 1966).

A curvilinear relationship exists between ovulation rate and herbage allowance or pre-grazing herbage mass. At the same herbage allowance, an increase in pre-grazing herbage mass will increase ovulation rate (Rattray *et al.* 1983). At higher herbage allowances this relationship levels off, presumably due to a greater selection and accessibility to the herbage on offer. Apparently a high proportion of green material is essential as herbage composition and feeding value accounts for some of the increased response in ovulation rate (Smith *et al.* 1981).

Different responses to feeding level also occur between heavy and light ewes. Heavy ewes in good condition are not as sensitive to changes in feeding level as light and thin ewes (Rattray *et al.* 1983). Thus flushing heavy ewes may not be as beneficial as flushing medium or light weight ewes. To the author's knowledge there was, prior to this study, no information on the relationship between SSH and reproductive performance in the literature pertaining to New Zealand conditions.

The choice of an appropriate time for flushing becomes an important decision, particularly in relation to herbage growth rates and herbage allowance for the ewes. Most research has suggested that flushing should commence 2 or 3 weeks before mating (pre-mating period) (Coop 1966; Gunn *et al.* 1990). Numerous researchers have shown that there is a close relationship between herbage allowance and post-grazing herbage mass and their effect on breeding ewe performance (Rattray *et al.* 1983; Rattray and Clark 1984; Hawker 1985). Flushing for 3 weeks prior to mating will be most effective when herbage is offered at 3-4 kg DM/ewe/day, at a pre-grazing herbage mass of 2500 kg green DM/ha and a post-grazing herbage mass of 1500 kg DM/ha (Rattray *et al.* 1987). A feeding level of 1.5 x maintenance is recommended for flushing (Rattray 1986) even though higher levels are suggested for particularly light ewes.

Most overseas studies suggest that an increase in pre-mating liveweight of the breeding ewes will increase lamb production (Gunn 1983). Ewes losing weight over mating had fewer lambs than ewes maintaining weight, while both of these scenarios resulted in fewer lambs per ewe than in ewes gaining liveweight. Lamb production is likely to be closely related to the pattern of liveweight change of the ewes during the mating period (Gunn and Maxwell 1989).

In addition to the productive performance of breeding ewes, ewe wool growth rate is at its highest, and is most responsive to feeding, during this period (Hawker *et al.* 1984; Hawker 1985). There is a consistent curvilinear relationship between wool growth and herbage allowance during autumn. At the same herbage allowance, fat/heavy ewes gain less liveweight but grow more clean wool than thin/light ewes. To maximize wool production, it is generally recommended that ewes be as heavy as possible during the summer-autumn period, as this period coincides with the period of maximum wool growth rate. This can be achieved (within seasonal constraints) by providing high quality feed to the ewes after weaning which is also consistent with achieving high reproductive performance.

Ewe body condition is not the sole factor influencing ovulation rate and response to herbage allowance. Initial liveweight and breed also account for differences. Ewes with higher initial liveweights (53-57 kg) have higher ovulation rates than their counterparts (43-45 kg) (Smith *et al.* 1981). Some specific strains of Romney were found to be less sensitive to herbage allowance than other strains. In one study, the Waihora Romney had the highest ovulation rate, followed by the

Coopworth and then the Romney, indicating the influence of genetic merit on ovulation rate (Smith *et al.* 1981; Rattray *et al.* 1983; Rattray *et al.* 1987).

However, the period prior to and during mating, and hence the period of flushing, coincides with the period when herbage growth rates tend to decline due to decreases in soil moisture content. Short pastures of low nutritive value are likely to occur and this can affect feed availability to the grazing animals.

Pregnancy and lactation

During the period of pregnancy, foetal growth and litter size (as well as ewe maintenance) will determine the nutrient requirements of breeding ewes and therefore herbage allowance must consider both the maintenance of ewe body condition and foetal development.

Up to mid pregnancy, maintenance requirements are based only on ewe liveweight as the contribution of the conceptus to total liveweight and nutrient requirements is small and therefore ewe intake is relatively low. Subsequent increases in intake need to occur in late pregnancy as the growth of foetus is increasing. In late pregnancy, a target sward height of 2 cm is appropriate for winter- and spring-lambing ewes in good body condition (condition score of 2.5-3.0). These low sward heights would be detrimental for ewes in poor condition as they might lose liveweight which could not be recovered subsequently (Morris *et al.* 1993a; Morris *et al.* 1993b).

During the lactation period, a sufficient supply of nutrients is required for body maintenance and milk production for the suckling lambs in addition to the maintenance requirements of their dams. Zero liveweight change occurred at herbage allowances of 4 kg DM/ewe/day (Rattray *et al.* 1982). Furthermore, twin-suckling ewes lost more weight or gained less weight than single-suckling ewes (-8 to 1 kg *vs* -6 to 5 kg) reflecting a higher milk production in twin-suckling ewes (Rattray *et al.* 1982).

Intake of single- and twin-rearing ewes is restricted when they graze swards at or below 3.5 cm height. Swards maintained at 5-7 cm during the lactation period are recommended to achieve maximum production in single- and twin-rearing ewes (Parker and McCutcheon 1992).

Herbage allowance becomes obviously important in the first 4 to 6 weeks of lactation as this is the time of peak ewe milk production (Peart 1967). This is particularly so for twin-rearing ewes because they require higher energy intakes than single-rearing ewes for their body maintenance and milk production (Geenty and Rattray 1987). In addition, fat ewes have higher milk production than thin ewes, particularly during restricted feeding. This is because fat ewes have body reserves which can act as a buffer to support milk production (Rattray 1986).

PURPOSE OF THE STUDY

Most relationships between herbage intake and production developed over the last twenty years in New Zealand are based on the herbage allowance method of allocating pasture. As described earlier, SSH guidelines mostly refer to overseas research reports. Corresponding guidelines under New Zealand pastoral conditions are limited with the exception of Parker and McCutcheon (1992), Morris *et al.* (1993a), Morris *et al.* (1993b) and Morris *et al.* (1994) who provided guidelines for ewes during pregnancy and lactation under continuous stocking grazing management systems. Corresponding guidelines for the mating period do not exist.

This trial was therefore designed to establish the relationship between SSH, intake and ewe performance, and to develop grazing management guidelines for breeding ewes continuously stocked in the late summer-autumn period (prior to and during mating).

CHAPTER TWO

EFFECT OF CONTINUOUS STOCKING OF BREEDING EWES AT DIFFERENT SWARD SURFACE HEIGHTS DURING THE LATE SUMMER-AUTUMN ON HERBAGE INTAKE AND PRODUCTIVITY

ABSTRACT

Continuous stocking management is preferred by many New Zealand sheep farmers during the late summer-autumn period. At present, there are no guidelines available to farmers that define the optimum sward conditions for continuous stocking management of ewes leading up to, and during, the mating period. Three different nominal sward surface heights (SSH) (2, 4, and 6 cm) replicated twice were used for a trial with 14 mixed age breeding ewes per treatment (n=84 ewes) continuously stocked from February to April 1994. The pastures consisted of predominantly 10-year old ryegrass (*Lolium perenne*), white clover (*Trifolium repens*) and browntop (*Agrostis capillaris*). Sward heights were measured weekly throughout the trial. Herbage intakes by the ewes were determined indirectly from faecal output using chromic oxide controlled release capsules and *in vitro* digestibility of digesta samples obtained from oesophageal-fistulated sheep run with the ewes. The average actual sward surface heights for the 2, 4, and 6 cm SSH treatments were 2.7 *vs* 4.3 *vs* 6.1 cm (± 0.05 cm (SEM), $P<0.001$). The pasture characteristics in terms of herbage mass, dead matter content and organic matter digestibility (OMD) for the 2, 4, and 6 cm SSH treatments were: 2723 *vs* 3880 *vs* 4337 (± 204 kg DM/ha, $P<0.05$); 69.74 *vs* 64.62 *vs* 51.37 (± 2.78%, $P<0.05$); 66.52 ± 0.85 *vs* 60.29 ± 0.90 *vs* 69.56 ± 0.84% ($P<0.01$). The daily liveweight gain, condition score, wool growth rate and mean fibre diameter for ewes grazing the 2, 4, and 6 cm SSH treatments were: 103 *vs* 122 *vs* 195 (± 15 g/day, $P<0.05$); 2.89 *vs* 3.05 *vs* 3.23 (± 0.06 condition score units, $P<0.1$); 1.30 *vs* 1.26 *vs* 1.41 (± 0.03 mg/cm^2/day, $P<0.1$); 43.01 *vs* 44.07 *vs* 44.48 (± 0.35 microns, $P>0.1$). The results suggest that swards of at least at 6 cm height are required to support adequate liveweight gain and condition score of breeding ewes in the period prior to and during mating. The accumulation of weed and dead material appear to be the major problems limiting intake and ewe performance.

Keywords Continuous stocking; late summer-autumn; sward height; breeding ewes

INTRODUCTION

The late summer-autumn period in New Zealand pastoral sheep production systems is a time when herbage growth rates tend to decline, often resulting in a shortage of pasture. This period coincides with mating, when breeding ewes are required to maintain or increase their body condition so as to achieve high ovulation rates and hence high lambing percentages (Coop 1966).

In this period, a continuous stocking management is preferred by many sheep farmers, particularly in the summer-dry areas, because of difficulty in maintaining a grazing rotation due to the decline in herbage growth rates. This form of grazing management will also encourage the development of a dense sward and the maintenance of clover in the sward.

Under continuously stocked systems, sward surface height (SSH) is a common parameter used as the basis to control sward state, herbage intake and animal performance (Maxwell 1985) as animals show a consistent response to variation in sward height. The advantages of SSH over herbage mass as an indicator of herbage production and animal intake are well established, at least in the United Kingdom (Hodgson 1990; Chestnutt 1992).

Guidelines for pregnant and lactating ewes under continuously stocked systems have been developed for New Zealand conditions (Parker and McCutcheon 1992; Morris *et al.* 1993a; Morris *et al.* 1993b). For the period prior to and during mating, most overseas researchers have suggested that a sward maintained at a height of between 4 and 6 cm is likely to achieve optimum pasture production and sward structure as well as good performance of breeding ewes

(Hodgson *et al.* 1986; Maxwell and Treacher 1987; Orr *et al.* 1990). Furthermore, Gunn *et al.* (1992) found that grazing swards below 3.5 cm in the pre-mating period reduced the ewe liveweight, body condition and reproductive performance. Swards maintained at 3.5-4 cm during the pre-mating period might be allowed to decline to about 2 cm in early pregnancy as this had little effect on reproductive performance. However, with exception of the report by Burnham *et al.* (1994), corresponding guidelines under New Zealand conditions are not available.

This trial was therefore designed to define the relationship between sward surface height (SSH), herbage intake and animal production in breeding ewes during the late summer-autumn period.

MATERIALS AND METHODS

The trial was conducted at Keeble Farm, Massey University, 5 km south of Palmerston North. Six paddocks ranging in area between 1.0 and 1.9 ha were used for the trial and were stocked at a rate of 14 breeding ewes/ha. The paddocks were randomly assigned to three different sward height treatments, nominally 2, 4, and 6 cm SSH, replicated twice. Treatments will henceforth be referred to by the nominal SSH. The pastures consisted of predominantly 10-year old ryegrass (*Lolium perenne*), white clover (*Trifolium repens*) and browntop (*Agrostis capillaris*) swards, and were prepared to the assigned sward heights using non-trial ewes over a period of 10 weeks prior to the trial. Non trial ewes were added or subtracted throughout the trial to maintain the nominal sward height on each of treatment replicate paddocks.

Eighty-four mixed age (4-8 years old) Border Leicester x Romney ewes were selected, weighed and had an initial midside patch cleared on the right hand side (Bigham 1974) on 26 January 1994. The midside patch was re-clipped on 22 February (27 days later) to provide a pre-treatment (covariate) estimate of wool growth rate. Ewes were randomly allocated to the assigned treatments on 22 February (d0 of the trial) and were continuously stocked until 13 April (d50). Unfasted liveweights were recorded on 22 February (d0), 7 March (d13), 18 March (d24) and 13 April (d50). The ewes were condition scored on d0 and d50 using the 5 point scale of Jefferies (1961).

Mating commenced on 14 March (d20) with one harnessed Coopworth ram assigned to each of the six paddocks. Mating marks were recorded and crayon colours changed on 28 March (d34). The rams remained with the ewes until d50. The ewes were run together after ram removal until lambing and were managed under a rotational stocking system which restricted herbage intake to a maintenance level (approximately 1 kg DM/ewe/d). Pregnancy status was determined by ultrasound on 3 June (d101). Lamb birth rank, sex and birth weight were recorded at birth and lambs were identified to their dam.

Pasture Measurements

Pasture measurements were taken every week during the trial using a Hill Farming Research Organization (HFRO) sward stick (Barthram 1986). The sward surface height (SSH) was determined by taking the average of 50 readings on each measurement day on the same diagonal path within each paddock.

Herbage mass was estimated by cutting four randomly selected 0.18 m^2 quadrats to ground level in each paddock on 10 March (d16), 23 March (d29) and 14 April (d51). Herbage samples were then washed to remove soil contamination, oven-dried at 80° C to a constant weight, and weighed to determine dry weight. Green herbage mass was derived from the product of calibrated herbage mass and the percentage difference between live and dead material, i.e green herbage mass= calibrated herbage mass x (100%-% dead material).

Botanical composition was determined by cutting the herbage adjacent to each quadrat, bulking within each paddock and sub-sampling before separation of the sub-sample into grass, clover, weed and dead matter components. It was also assessed through a sub-sample of the extrusa of oesophageal fistulated animals (see below) using a 100 grid point counting method (Clark and Hodgson 1986).

Animal Measurements

On 28 February (d6), 8 ewes in each treatment replicate were dosed with a single chromic oxide controlled release capsule (CRC; 3.0 cm core of pressed tablet, 65% Cr_2O_3 matrix and 9.0 mm orifice; Captec (NZ) Ltd., Auckland). Thereafter, two 5-day periods of faecal sampling occurred, commencing on 7 March (d13, 7 days after insertion) and 19 March (d25, 19 days after insertion). Faecal collection was conducted in the morning (0900-1100 h) and each ewe was sampled per rectum. Faecal samples were oven-dried at 60°C for up to 72 hours to a constant weight. The samples were pooled on an individual animal basis over the 5-day collection period, with the total weight being approximately 6 g/ewe/period.

The chromium concentration of faeces was assessed by using atomic absorption spectrophotometry (Parker *et al.* 1989). The rate of chromic oxide release from the CRC ranged between 134 and 136 mg Cr/day as determined by measurement of plunger travel in the CRC recovered, after slaughter, from four ewes grazed together with the treatment ewes within the low and medium height swards (2 and 4 cm) for 14 days (d17-d31).

Four mixed age oesophageal fistulated (OF) wethers were used to obtain extrusa samples for the estimation of digestibility of herbage consumed by the ewes. These wethers were rotated around the experimental paddocks within each period of faecal collection. The extrusa samples were freeze-dried and analyzed for *in vitro* digestibility (Roughan and Holland 1977) and a sub-sample of the extrusa was obtained to assess the botanical composition.

Wool samples were again clipped from the midside on 13 April (d50). The 22 February and 13 April samples were conditioned under 20°C and 65% relative humidity for seven days prior to scouring. The greasy weight and clean weight were obtained before and after scouring, respectively. Mean fibre diameter (MFD) of scoured samples was measured using the airflow technique (Ross 1958) for samples weighing more than 2.5 g and using the projection microscope for samples weighing less than 2.5 g.

Statistical Analysis

Data were analysed using the Statistical Analysis System computer package (SAS 1985). The SSH treatment x replicate mean square was used as the denominator to test for the effect of SSH treatment on intake, daily liveweight gain and midside wool growth of ewes and on lamb birth weight. The proportion of ewes lambing relative to those mated ("proportion lambing") and the proportion of ewes lambing which had multiples ("proportion of multiples") were analysed as binomial traits using the SAS procedure for categorical data modelling (logit transformation). Data were expressed in terms of means (± S.E.M). Differences between group means were tested using the Least Significant Differences Test (SAS 1985).

RESULTS AND DISCUSSION

Pasture Production

Table 2 presents the pasture data during the trial period. At the beginning of the trial (d0), when ewes were introduced to the assigned paddocks, the sward heights were 2.8, 4.2, and 5.8 cm. The sward heights at the end of the trial (d50) were 2.6, 4.1, and 5.9 cm. The average sward heights across the period were 2.7, 4.3 and 6.1 cm for the (nominally) 2.0, 4.0, and 6.0 cm SSH treatments. The sward heights during the trial period are presented in Figure 2.

The mean herbage masses were 2723, 3880, and 4337 kg DM/ha for the 2.0, 4.0, and 6.0 cm SSH treatments, respectively. The 2.0 cm SSH treatment had lower ($P<0.05$) herbage mass than the other two treatments. Corresponding green herbage mass was significantly different ($P<0.05$) across all treatments with the 2.0 cm SSH treatment being the lowest.

Table 2 Means of sward height, herbage mass, botanical composition and *in vitro* digestibility of the three sward surface height (SSH) treatments (Mean±S.E.M.).

	Sward surface height (SSH) treatment		
	2 cm	4 cm	6 cm
Sward surface height (cm)	2.7 ± 0.05 ^{a}	4.3 ± 0.05 ^{b}	6.1 ± 0.05 ^{c}
Herbage mass (kg DM/ha)			
total	2723 ± 204 ^{a}	3880 ± 204 ^{b}	4337 ± 204 ^{b}
green[1]	832 ± 111 ^{a}	1373 ± 111 ^{b}	2104 ± 111 ^{c}
Botanical composition (%)			
from calibrations			
grass	26.34 ± 3.29 ^{a}	29.02 ± 3.29 ^{a}	45.41 ± 3.29 ^{b}
clover	3.89 ± 1.46	6.36 ± 1.46	2.96 ± 1.46
weed	0.04 ± 0.15	0.00 ± 0.15	0.26 ± 0.15
dead matter	69.74 ± 2.78 ^{b}	64.62 ± 2.78 ^{b}	51.37 ± 2.78 ^{a}
from OF samples			
grass	50.49 ± 2.52	52.12 ± 2.22	60.40 ± 1.43
clover	1.06 ± 1.30	1.93 ± 1.14	4.18 ± 0.74
weed	24.20 ± 2.08 ^{b}	19.62 ± 1.83 ^{a,b}	13.36 ± 1.18 ^{a}
dead matter	24.24 ± 2.54	26.33 ± 2.23	22.06 ± 1.44
Extrusa analysis			
N (%)	2.84 ± 0.08 ^{b}	2.38 ± 0.09 ^{a}	2.93 ± 0.08 ^{b}
DMD(%)	66.18 ± 0.78 ^{b}	59.99 ± 0.83 ^{a}	68.85 ± 0.78 ^{b}
DOMD(%)	55.85 ± 0.77 ^{a}	52.44 ± 0.81 ^{a}	60.53 ± 0.76 ^{b}
OMD(%)	66.52 ± 0.85 ^{b}	60.29 ± 0.90 ^{a}	69.56 ± 0.84 ^{b}
M/D value (MJME/kgDM)	8.94 ± 0.12 ^{a}	8.39 ± 0.13 ^{a}	9.68 ± 0.12 ^{b}

^{a,b,c} Mean values in the same row with different superscript letters differed significantly (P<0.05).

1 calculated from herbage mass.

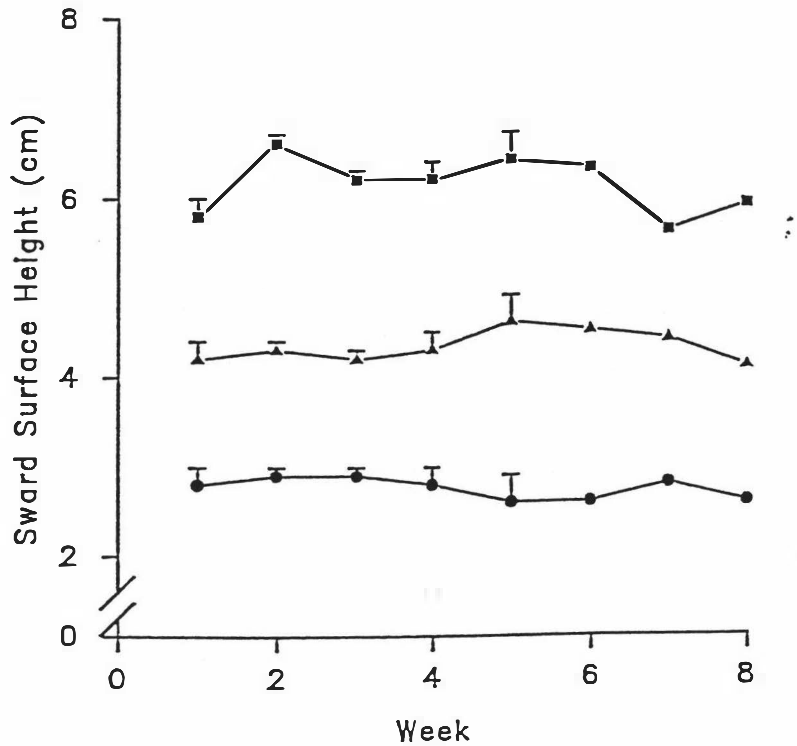

Figure 2 Mean (± S.E.M.) sward surface height (SSH) measurements on the 2.0 cm (●), 4.0 cm (▲) and 6.0 cm (■) sward surface height treatments over the trial period.

These figures reflect the high proportion of dead material in the swards as shown by the determinations of botanical composition from cut herbage (69.74, 64.62 and 51.37% dead matter for the 2.0, 4.0 and 6.0 cm SSH treatments, respectively). This is a common characteristic of dry late summer pasture (Hawkins *et al.* 1993). Table 2 also shows that the proportion of grass increased and the proportion of dead material decreased as sward height increased, especially between the 4.0 and 6.0 cm nominal SSH. However, there were no significant differences in clover and weed content across the SSH treatments. The botanical separation of extrusa samples revealed a similar situation only for the proportion of weed which decreased as sward height increased with the 6.0 cm SSH treatment being the lowest ($P<0.05$).

The high proportion of weed in all SSH treatments was due to the presence of Californian thistle (*Cirsium arvense*) which accumulated during the trial period. The high proportion of grass and low proportion of dead material in extrusa samples reflected the grazing selection as animals consumed diets containing more leaf and less dead material than the swards to which they had access (Arnold 1981).

The pasture dry matter and organic matter digestibility (DMD and OMD) of the 4.0 cm SSH treatment were lower ($P<0.05$) than those of the 2.0 cm and 6.0 cm SSH treatments, while the 2.0 and 4.0 cm SSH treatments had lower digestible organic matter in the dry matter (DOMD) than the 6.0 cm treatment. The dry matter digestibility (DMD) of all sward treatments was below 70% and hence the pasture can be categorized as a low to medium quality forage (Ulyatt 1970). This range of digestibility might limit ewe intake and performance due to the high proportion of non-digestible components in the diet (Rattray 1978; Jagusch *et al.* 1978), and in the current trial reflected the high proportion of weed and dead material.

The predicted M/D values were lower ($P<0.05$) in the 2.0 and 4.0 cm SSH treatments than in the 6.0 cm SSH treatment. The low M/D values can be attributed to the high proportion of dead material as the swards became mature which led to the decline in their nutritive values. The high proportion of weed as reflected in the extrusa samples also contributed to the low M/D values. This reduced the digestibility of organic matter in the dry matter (DOMD) and consequently reduced the sward nutritive values (i.e M/D values). All values (8.39-9.68 MJ ME/kg DM) were lower than the recommended level of good quality pasture (10-12 MJ ME/kg DM) (Rattray and Jagusch 1978). However, the values were in agreement with Ulyatt *et al.* (1980) who found that mature swards had M/D values ranging from 8-10 MJ ME/kg DM.

Ewe Intake and Productive Performance

Table 3 presents the ewe intake data over the trial period. The faecal dry matter output (FOE) and faecal organic matter output (FOM) were similar in all treatments. The dry matter intakes (DMI) of ewes across all treatments were similar ($P>0.05$). However, the organic matter intake (OMI) of ewes on the 4.0 cm SSH treatment was lower than that of ewes on the other treatments. The increased difficulty in harvesting herbage due to low sward surface height did not appear to depress ewe intake. The high proportions of dead material in the 2.0 and 4.0 cm SSH treatments probably limited the accessibility of the grazing ewes to encounter green herbage mass in the swards. This was in agreement with Rattray and Clark (1984) who noted that high herbage mass with high proportion of stem and pseudostem might reduce the availability of green leaf of herbage mass in the grazed horizon and hence depress ewe intake.

Effects of sward height treatments on ewe productivity are presented in Table 4. Ewe liveweights were generally greater on the 6.0 cm SSH treatments than on the 2.0 or 4.0 cm SSH treatments (but significantly so only on d50), reflecting greater ($P<0.05$) daily liveweight gain on the 6.0 cm SSH treatment compared to the other treatments. Ewes were in good condition (body condition score 3.0) at the start of the trial and this was maintained throughout the trial period. The daily liveweight gain over the trial period was consistent with the pattern of metabolizable energy intake (MEI). The MEI of ewes grazing the 2.0 cm SSH treatment was similar to the estimated maintenance requirements for a 65 kg ewe (13.0 MJ ME/ewe/day) (Geenty and Rattray 1987).

Table 3 Effects of sward surface height (SSH) treatments on DMI (Dry Matter Intake), OMI (Organic Matter Intake), DOMI (Digestible Organic Matter Intake) and MEI (Metabolizable Energy Intake) (Mean ± S.E.M.).

	Sward surface height (SSH) treatments		
	2 cm	4 cm	6 cm
Faecal output estimate (FOE) (g DM/d)	422.2 ± 22.2	434.0 ± 19.9	461.1 ± 19.2
Faecal organic matter output (FOM) (g/d)	343.4 ± 18.7	359.3 ± 16.7	393.3 ± 16.2
DMI (kg/ewe/day)	1.25 ± 0.08	1.09 ± 0.07	1.49 ± 0.07
OMI (kg/ewe/day)	1.03 ± 0.07 [a,b]	0.91 ± 0.06 [a]	1.30 ± 0.06 [b]
DOMI (kg/ewe/day)	0.68 ± 0.05 [a]	0.55 ± 0.04 [a]	0.91 ± 0.04 [b]
MEI (MJ ME/ewe/day)	10.93 ± 0.78 [a]	8.84 ± 0.70 [a]	14.51 ± 0.68 [b]

[a,b] Mean values in the same row with different superscript letters differed significantly (P<0.05).

In fact however, these ewes gained liveweight. The favourable climatic conditions during the trial period and reduced exercise under continuous stocking are both likely to have reduced the energy required for grazing activity relative to the average values assumed in the ARC recommendations (ARC 1980). This particularly appears to apply to the ewes grazing low to medium quality pastures (ARC 1980). Ewes grazing the 6.0 cm treatment achieved a MEI above the recommended maintenance requirement and gained 195 g/d over the trial period.

The low content of green material (% green DM/ha) and hence its accessibility (kg DM/ha) in the 2.0 and 4.0 cm SSH treatments limited ewe daily liveweight gain.

Table 4 Effects of sward surface height (SSH) treatments on ewe liveweight, daily liveweight gain and condition score, wool growth rate and mean fibre diameter (Mean ± S.E.M.).

	Sward surface height (SSH) treatments		
	2 cm	4 cm	6 cm
Ewe liveweights (kg)			
d 0	60.23 ± 0.53	61.23 ± 0.53	61.34 ± 0.53
d 13	63.98 ± 0.68	63.86 ± 0.68	67.05 ± 0.68
d 24	63.95 ± 0.76	64.95 ± 0.76	66.80 ± 0.76
d 50	65.38 ± 0.78 [a]	67.34 ± 0.78 [a]	71.11 ± 0.78 [b]
Daily liveweight gain (g/day)	103 ± 15 [a]	122 ± 15 [a]	195 ± 15 [b]
Condition score			
d 0	3.07 ± 0.03	3.07 ± 0.03	2.98 ± 0.03
d 50	2.89 ± 0.06	3.05 ± 0.06	3.23 ± 0.06
Wool growth rates ($mg/cm^2/day$)	1.30 ± 0.03	1.26 ± 0.03	1.41 ± 0.03
Mean fibre diameter (microns)	43.01 ± 0.35	44.07 ± 0.35	44.48 ± 0.35

[a,b] Mean values in the same row with different superscript letters differed significantly (P<0.05).

Smeaton *et al.* (1981) also reported that a high level of dead material (75%) reduced the green herbage mass and resulted in lack of response in liveweight gain. However, the results are in contrast to those reported by Gunn *et al.* (1992) who found that ewe body condition started to fall as sward height declined to below 3.5 cm. The discrepancy was perhaps due to the higher initial body condition of ewes in the current trial (approximately 3.0 compared to 2.5).

There were no significant effects of sward height treatment on wool production (i.e. wool growth rate and mean fibre diameter). This is consistent with results reported by Burnham *et al.* (1994). The fact that ewes can produce sound wool on extremely short pasture has also been noted previously (Wickham 1968) even though it is not recommended to leave ewes in such sparse grazing conditions. The low to medium quality pasture with low level of green herbage mass, such as in the current trial, might limit the potential wool production as high quality feeds are required to sustain maximum wool growth rate in the autumn period.

Reproductive Performance of The Ewes

Table 5 shows the effects of sward height treatment on ewe reproductive performance. There were 28 ewes in each treatment of which 26 ewes (93%) gave birth in each case. The numbers of ewes having multiple lambs from those that gave birth were 13 ewes (50%) in the 2.0 and 6.0 cm SSH treatments and 12 ewes (46%) in the 4.0 cm SSH treatment. The sward height treatments did not significantly affect any measure of ewe reproductive performance (i.e. lamb birth weight, proportion of lambing and proportion of multiple lambings). This is similar to the results of Burnham *et al.* (1994). The high liveweight of the ewes, which weighed over 60 kg and had body condition scores of approximately 3.0 which has been maintained throughout the trial period might explain the unresponsiveness of ewes to the feeding level over the trial period (Rattray *et al.* 1983). A critical band of body condition which affects ovulation rate has also been reported by Gunn *et al.* (1991) who noted that optimum reproductive

Table 5 Effects of sward surface height (SSH) treatments on lamb birth weight, proportion lambing and proportion of multiples (Mean ± S.E.M.).

	Sward surface height (SSH) treatments		
	2 cm	4 cm	6 cm
No. ewes	28	28	28
Lamb birth weight (kg)	5.9 ± 0.2	6.2 ± 0.2	5.5 ± 0.2
Proportion lambing (%)	2.56 ± 0.73[1] (93)[2]	2.56 ± 0.73 (93)	2.56 ± 0.73 (93)
Proportion of multiples (%)	-2.32E-17 ± 0.39 (50)	-0.15 ± 0.39 (46)	-2.32-17 ± 0.39 (50)

[1] logit-transformed
[2] back-transformed

performance can be reached with ewes in body condition score around 2.5 at 2 to 3 weeks prior to mating.

In conclusion, the trial suggests that summer-autumn swards of low to medium quality pasture should be maintained at least at a height of 6.0 cm to support an adequate performance by breeding ewes prior to and during mating. Lower sward heights (4.0 cm) will achieve the same result where pastures are of high quality and have an associated high proportion of green material (Burnham *et al.* 1994). These levels are lower than the 6.0-8.0 cm swards recommended for late summer in order to build up reserves of good quality herbage and maintain ewe intake prior to and during mating. Grazing management should aim to minimize the accumulation of weed and dead material in the swards as these factors limit ewe intake and performance. This can be achieved by controlling pasture growth throughout the spring-summer period, as suggested by Baars *et al.* (1981), to maintain pasture quality into the autumn.

CHAPTER THREE

GENERAL DISCUSSION

EVALUATION OF THE PRESENT STUDY

This chapter will review the experimental approach conducted in Chapter 2 and place the results into the context of New Zealand pastoral sheep farming systems.

As stated in the previous chapter, the objectives of this study were to establish a relationship between sward surface height (SSH), herbage intake and breeding ewe productivity, and to develop grazing management guidelines appropriate for breeding ewes continuously stocked in the period prior to and during mating. Corresponding guidelines have been well-researched overseas. However, their adaptation to New Zealand pastoral conditions must consider local natural factors such as climate, topography and soil type, as these will determine herbage quantity and quality and hence animal intake and performance. Guidelines based on sward surface height (SSH) are known to be well suited to continuous stocking and are readily understood by farmers.

The study confirms that ewe intake and productivity are closely related to sward surface height. Continuously stocking breeding ewes on low to medium quality pastures at sward surface heights of at least 6 cm during the late summer-autumn supports adequate productive performance in breeding ewes. A previous study by Burnham *et al.* (1994) confirmed that a similar ewe performance level can be achieved in lower sward heights (i.e. 4 cm).

The relationships between SSH and ewe dry matter intake (DMI), metabolizable energy intake (MEI), daily liveweight gain and wool growth rate derived from Burnham *et al.* (1994) and the trial reported here are presented in Figure 3.

Ewe DM and ME intake in the current trial was lower than those reported in the previous study and this was mostly attributed to the high accumulation of weed and dead material. It also shows that there is an increase in daily liveweight gain with increasing SSH up to 6 cm, where it declined beyond this level, suggesting that there is no advantage to have swards higher than 6 cm height. However, wool growth rates were not significantly affected by SSH treatments in both studies. It also demonstrates that there is a trend for ewe performance to increase as sward height increases from 4 to 6 cm.

Continuous stocking systems open the possibility for ewes to have unrestricted access to the entire grazing area, and therefore to consume all available plant material in the sward. In these situations, the quality and quantity of the herbage become crucial in determining intake. The accumulation of weed and dead material (poorly digestible components in the diet) is likely to offset the accessibility of green herbage mass to ewes. This non-nutritional factor is likely to restrict ewe intake. It leads to a decline in herbage digestibility, particularly when swards are of lower heights (i.e. 2.0 and 4.0 cm), and therefore leads to a restriction in intake. This is also a possible explanation for the discrepancy between the results of the trial reported here and those reported by Burnham *et al.* (1994).

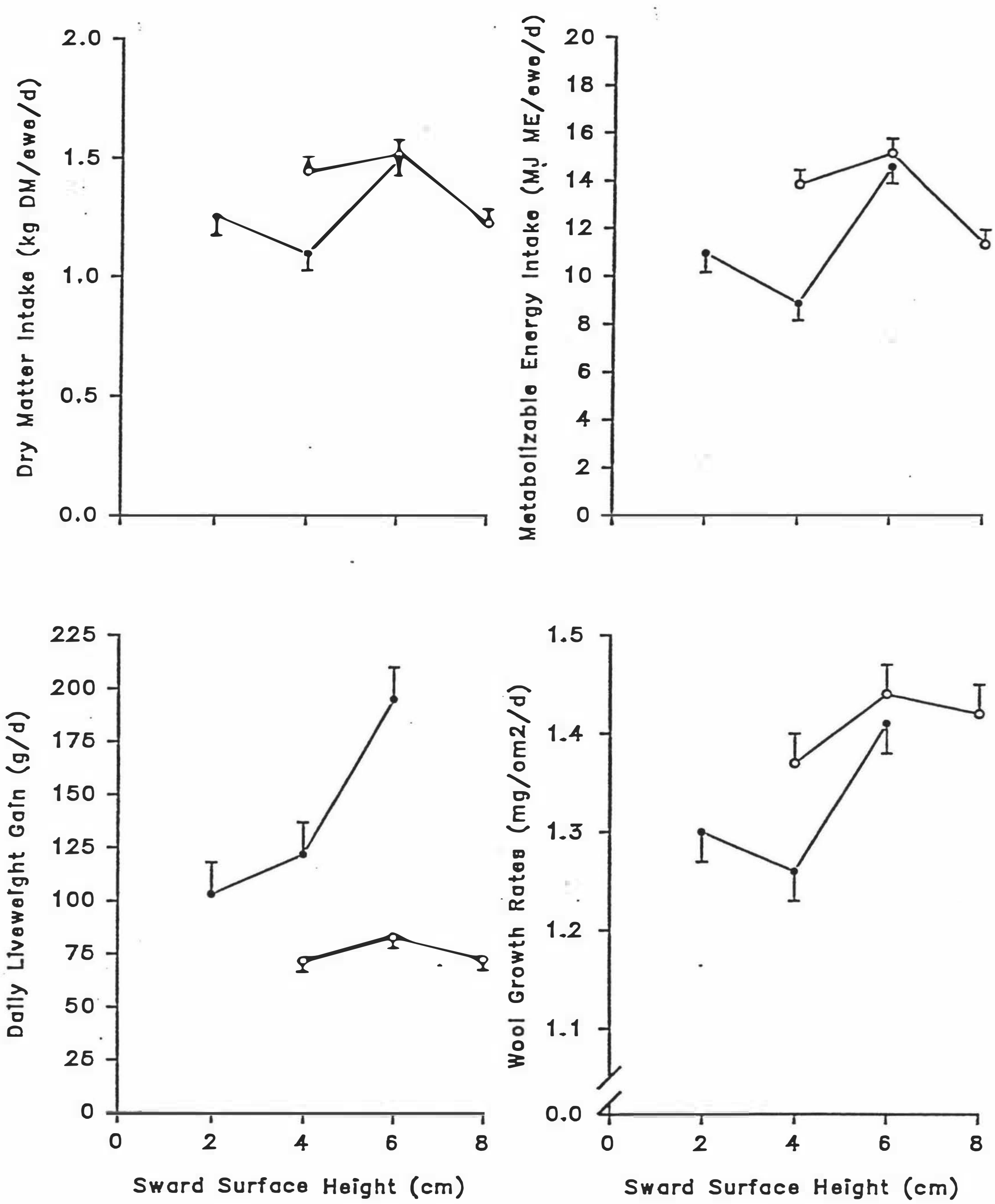

Figure 3 The effect of sward surface height (SSH) treatments on ewe dry matter intake (DMI), metabolizable energy intake (MEI), daily liveweight gain and wool growth rates reported by Burnham *et al.* (1994) (O) and the current trial (●).

The higher organic matter digestibility (OMD) in that study resulted in a higher energy intake. In addition, the OMD declined as SSH increased from 6 to 8 cm, and hence depressed ewe intakes. This indicates that there is possibly no advantage for sward surface height to be higher than 6 cm to support breeding ewes prior to and during mating. In contrast, the 6.0 cm SSH treatments in the trial reported here, contained a green herbage mass of approximately 2000 kg DM/ha, similar to that recommended by Rattray (1978) for the pre-mating period. Therefore, the amount of live leaf in the sward throughout the autumn period is the factor exerting the greatest impact on animal performance (Hodgson 1990).

In terms of pasture performance, maintaining swards at 6.0 cm height will also optimize the production and utilization of mixed grass/clover swards (Orr *et al.* 1990). Swards of 6 cm height in the autumn period can be grazed down to 2-3 cm height in winter to remove mature leaf and accumulated dead material, as ungrazed herbage remaining in the autumn will often decay and contribute to the death of underlying tillers in the colder temperatures occurring during the winter months. Morris *et al.* (1993b) supported this idea as they found that June-lambing ewes can graze much shorter pastures (2.0 cm SSH) over the last month of pregnancy and maintain their productivity, provided that they were in good condition (body condition score 2 - 3). In addition, maintaining swards at 6.0 cm height during the autumn will prepare the pasture for the following season without causing any long term deterioration in the sward. Apparently, this scenario is unlikely to apply if swards are maintained at extremely low height (i.e 2.0 cm) in the late summer-autumn, a situation that frequently occurs in a drier than normal summer period, resulting in insufficient herbage supply for animals. This scenario might also require a prolonged period of pasture recovery to provide sufficient growth in subsequent seasons.

In field trial situations, particularly of a short term duration, it is likely that sward height is maintained close to target level for the defined time period. However, under this scenario, it is difficult to obtain data on herbage growth rates that might ultimately affect the availability of herbage for the breeding ewes. Under grazing systems, adjustment in stocking rate is imperative as grazing pressure will determine sward conditions that affect herbage availability and hence, ewe intake and performance. At a stocking rate of 14 breeding ewes/ha in the current trial, the targeted SSH was successfully maintained and herbage mass remained relatively constant throughout the trial period. Therefore, differences in ewe intake and performance can be related to the assigned SSH and sward conditions.

Under practical situations however, it is often not realistic to maintain swards at a constant height throughout the grazing period, even though serious consequences in ewe productivity might occur if swards are allowed to drift away from prescribed target levels. It may then be necessary to know animal responses to a range of sward heights.

A potential source of error in the digestibility values and hence variation in ewe intake estimates, is related to the oesophageal fistulated (OF) wethers grazing the SSH treatments to obtain extrusa samples being different to those of the trial animals (i.e. ewes). It is likely that wether sheep have a different diet selection or foraging strategy to ewes (Dove 1993). The use of one class (i.e. wethers) to establish the relationship between *in vivo* and *in vitro* digestibility is potentially irrelevant to other classes of stock with different levels of intake. The OF wethers came from different grazing areas, and were therefore not familiar with the sward being grazed. A longer period of adaptation than the two weeks allowed for in this trial is possibly justified.

The extrusa samples collected from wether sheep in the current trial contained a high proportion of green leaf and a low proportion of dead material compared to the cut herbage available to the ewes. This showed selection of green herbage in preference to dead material by the wether sheep. Assessment of the amount of green leaf can be conducted through botanical separation using either cut herbage or extrusa samples. Differences between live and dead material multiplied by total herbage mass will express the amount of green herbage mass in the sward.

Having noticed that the accumulation of weed and dead material in the current trial modifies the relationships between SSH - herbage intake - ewe performance, research is required whereby swards with high levels of green herbage mass are used to further determine the relationship between sward conditions and ewe performance in the period prior to and during mating.

The response of wool production to seasonal effects is well established (Rattray *et al.* 1987) and it requires high quality herbage during autumn to maximize wool growth rate. In addition, ewe liveweight should be kept as high as possible during summer-autumn, a situation achieved in the current trial. The lack of response in wool growth rate might be attributed to an 'emergence time' lag of 5-20 days before a change in wool growth can be measured above the skin (Rattray *et al.* 1987), suggesting that further research with longer time periods is required to obtain wool growth responses to feeding level, bearing in mind that wool growth rates are likely to be responsive during this period.

The introduction of ewes to the assigned SSH treatments occurred approximately three weeks prior to the commencement of mating, which is within the suggested time period to obtain a flushing response (Gunn *et al.* 1991). Trial ewes had initial (average) liveweights of 60 kg which increased as shown by their daily liveweight gain. In addition, ewes were in a body condition score of approximately 3.0 at the start of the trial which was maintained throughout the trial period. The unresponsiveness of reproductive performance to feeding level in the flushing period is in agreement with previous studies (Rattray *et al.* 1983; Burnham *et al.* 1994). The high liveweight and body condition are likely to affect the metabolic and endocrine status of the ewes which overrides the effect of contemporary nutrition (Rhind 1992). Therefore, ewes should be in a medium or intermediate range of body condition scores to procure reproductive responses to feeding level. A range of 2.5 - 2.6 has been suggested (Gunn 1983; Merrell 1990; Gunn *et al.* 1991) and body condition scores above or below this critical range will often show a lowered reproductive response to energy or feed intake. This unresponsiveness warrants a further investigation using breeding ewes of moderate condition (approximately 2.5) to obtain the effect of flushing on high quality pastures (herbage digestibility greater than 70%).

CONCLUSION

This trial has shown that under continuous stocking systems, swards maintained at a height of at least 6 cm support an adequate ewe intake, body condition and daily liveweight gain, provided that green herbage masses are maintained and proportions of weed and dead material are minimized.

It has also shown that maintaining high amounts of green material and minimizing accumulation of weed and dead material rather than sward height appear equally important factors influencing herbage digestibility and hence, animal intake and performance.

Grazing management in spring and summer inevitably has an effect upon sward conditions in the autumn. Herbage growth is at its maximum rate in spring suggesting that excess herbage accumulation is likely to occur. This must be controlled by suppressing reproductive plant growth, through either increased grazing pressure or, where terrain permits, closure of grazing area for conservation in order to maintain a high proportion of green leaf and to achieve an optimum herbage mass of 2000 kg DM/ha. Failure to maintain these sward conditions will result in the build up of dead material that will be carried through into the late summer and autumn periods when herbage growth rates subsequently decline.

The late autumn-winter period is a critical time of the year in an all grass wintering system as imbalances between herbage supply and demand are likely to occur. Farmers should therefore place grazing priority to particular classes of livestock and sell excess stock (i.e. culled ewes, weaned lambs), and therefore reduce winter feed demand.

This suggests that SSH maintained at 6.0 cm height during the autumn mating period is compatible with the prerequisite of having a reasonable feed bank before entering the winter period where herbage growth rates are at their lowest and usually fall behind animal feed requirements.

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APPENDIX I

ESTIMATION OF FEED INTAKE USING Cr_2O_3 AS A FAECAL MARKER

Estimation of faecal dry matter output from chromium atomic absorption reading

Estimation of faecal output estimate (FOE)

$$FOE = \frac{e1}{Cr \times 1.042} \qquad (1)$$

FOE	=	Faecal output estimate (g DM/d)
e1	=	chromium release rate (mm/d)
1.042	=	recovery factor (assumed that 100% of the chromium administered to the animal is recovered)

Chromium release rate is estimated by:

e1	=	linear density (mg/mm) x molecular weight (0.6843) x (initial-final matrix length)

Estimation of faecal organic matter (FOM)

$$FOM = FOE \times \%OM \qquad (2)$$

FOM	=	Faecal organic matter (g/d)
FOE	=	Faecal output estimate (g DM/d)
OM	=	Organic matter content of faecal material (%)

Estimation of intake

Estimation of dry matter intake (DMI)

$$DMI = \frac{FOE}{(1 - DMD)} \qquad (3)$$

DMI	=	Dry matter intake (kg/ewe/d)
FOE	=	Faecal dry matter output estimate (g DM/d)
DMD	=	Dry matter digestibility (%)

The calculation of feed intake can also be done on the basis of organic matter

Estimation of organic matter intake (OMI)

$$OMI = \frac{FOM}{(1 - OMD)} \qquad \textbf{(4)}$$

OMI	=	Organic matter intake (kg/ewe/d)
FOM	=	Faecal organic matter output (g OM/d)
OMD	=	Organic matter digestibility (%)

Estimation of digestible organic matter intake (DOMI)

$$DOMI = OMI \times OMD \qquad \textbf{(5)}$$

DOMI	=	Digestible organic matter intake (kg/ewe/d)
OMI	=	Organic matter intake (kg/ewe/d)
OMD	=	Organic matter digestibility (%)

Estimation of Metabolizable energy intake (MEI)

$$MEI = DMI \times M/D \text{ value} \qquad \textbf{(6)}$$

MEI	=	Metabolizable energy intake (MJ ME/ewe/d)
DMI	=	estimated from equation (3) above
M/D value	=	ME content of pasture measured at maintenance level of feeding (MJ ME/kg DM)

Estimation of M/D value

$$M/D \text{ value} = 0.16 \times DOMD \qquad \textbf{(7)}$$

DOMD	=	Organic matter digestibility of dry matter (%)
0.16	=	Correction factor for grasses, legumes, root crops (including leaves), other green foods, cereals, by products (CSIRO 1990)

APPENDIX II

TECHNIQUE TO ESTIMATE BOTANICAL COMPOSITION OF DIET SAMPLES COLLECTED FROM OESOPHAGEAL FISTULATES

Clark, D.A.; Hodgson, J. 1986.
Mimeograph, DSIR, Palmerston North.

INTRODUCTION

A number of methods have been used to provide the estimate of botanical composition of diet samples: hand dissection of fresh or freeze-dried samples, maceration followed by high powered microscope point analysis and point analysis of fresh samples. The hand dissection methods give quantitative estimates but are time-consuming and large amounts of digesta may be unidentifiable especially if sheep or goats are used or if freeze-dried material which is prone to shatter easily is used. Where plant components are larger, e.g. cows grazing long pasture, then hand dissection could be quicker and reasonably accurate.

The point analysis using a microscope can give a complete description of the whole diet. However, it is time-consuming and requires a high degree of training for complex diets. Point analysis measures area rather than mass so that relationships between area and mass need to be developed to ensure the method is quantitative. Errors are small if only green grass, clover and flat weeds are present, but if unusual components or dead matter are present then errors may increase.

The most commonly used technique is point analysis of fresh samples (or thawed, frozen samples). It is a quick method and subject to small errors if the diet mix is simple and components not extensively chewed.

TECHNIQUE

(1) Sample is thoroughly mixed then rinsed with tap water through a fine sieve (the loss of a small amount of unidentifiable matter occurs) to remove saliva and chlorophyll coloration. This makes identification much easier.

(2) Place a sample (20 g) onto a white tray (e.g. dissecting tray or photographer's developing dish) that has been marked with a grid of 200 points. Add sufficient water to dispense the sample evenly across the tray (some samples may need to be teased out to achieve this).

(3) Identify the material at each cross point on the grid. If material is in several layers a 'first hit' identification is used. A fine dissecting needle is helpful to turn pieces of leaf around, etc. Material is identified which is either on the cross-section, touching the cross-section or is closest to the point.

(4) Two sub samples of 200 points is appropriate with 2 people making the work much easier: one to identify and one to record. In this way, many samples can be identified in a half-day sitting. It is much faster if grass, clover, dead material and weeds are the only categories.

Figure 4 shows the relationship between the actual clover DM (%) and estimated clover DM (%) estimated by two people from a simple grass, clover, dead material mixture.

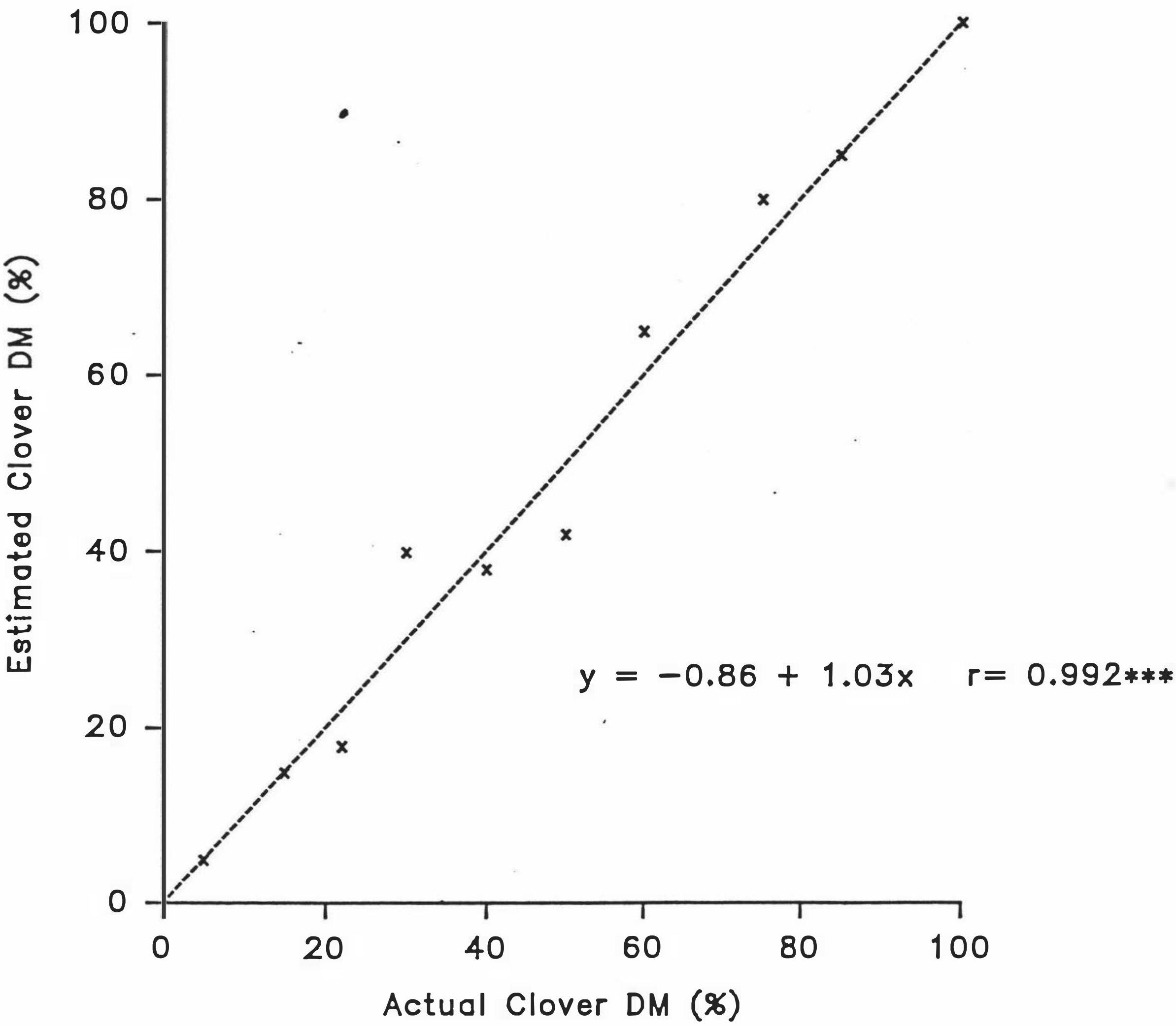

Figure 4 Relationship between clover DM (%) estimated by a point analysis technique and actual clover DM (%) by the operator.