THE EFFECTS OF LOSS OF SOWN TEMPERATE SPECIES ON THE PRODUCTION OF MERINO WETHERS

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SUMMARY

The study was based on part of a long term experiment which provided 15 years of data on plant species presence, greasy fleece weight (GFW) and seasonal liveweight change in fine woolled Merino wethers grazed at three set stocking rates (10, 20 and 30 dse/ha). Widely ranging losses of the sown phalaris and white clover were accompanied by ingress of other grasses, annual clovers and broad leaf weeds. Mean yearly values for GFW declined non-linearly with stocking rate increase, 5.49, 5.07 and 3.28 kg/sheep respectively, and decline in the stability of this production was reflected by increases in the c.v. (%) of annual values: 9.0, 11.5 and 20.2%. Local relationships, based on similar sheep, pastures and stocking levels, were used primarily to calculate metabolisable energy intake (MEI) from seasonal data for fleece corrected liveweight change (ca. 42 day intervals). Wheat was fed to the 30 dse/ha treatment when necessary and deductions made to both GFW and MEI on a metabolisable energy basis. A model based on power and linear functions was used to relate MEI and GFW to sown species presence and to an index of soil moisture stress (SMS). MEI was sensitive to sown species loss and served as an indicator of nutritional stress. For an 80% loss of sown species, the predicted losses in GFW were nil, 1.7 and 1.1 kg/sheep/year for the 10, 20 and 30/ha treatments. Results are discussed in relation to joint effects of set stocking rate, sown species loss and SMS on wool production and levels of calculated MEI. Issues of stress in grazing animal and risk are also discussed.

Keywords: stocking rate, sown species, wool, MEI

INTRODUCTION

In the 1960s the key factors for increasing animal production from temperate improved pastures were considered to be superphosphate, species and stocking rate. Highly fertilised sown pastures could produce more than 100 kg/ha/year of clean wool (Langlands and Bennett 1973). Decades later, sustainable production became an issue. At Chiswick, Armidale NSW we have continued some grazing experiments that commenced in the 1960s. Here we report results from 15 years of data for Merino wethers, showing long term effects of stocking rate and sown species loss on the stability of wool production and on levels of nutritional stress which may be encountered in the absence of supplementary feeding.

MATERIALS AND METHODS

Site and treatments

The experimental area (Big Ridge 1) was sown in 1958 to phalaris (*Phalaris aquatica* cv. Australian) and white clover (*Trifolium repens* cv. Huia). In 1963, sixteen plots, each 0.4 ha, were fenced and set stocking rates (10, 20 and 30 Merino wethers/ha) applied in 1964. The experiment, now in its 35th year, is divisible into three phases during which subsidiary treatments were included and/or stocking levels reduced on ethical grounds as the pastures degraded. Fourteen years of data reported here are from Phase 1 of the experiment (1964 to 1979) where the stocking rates (above) were unchanged except for a severe drought, commencing in 1965, when all sheep were removed. Measured amounts of wheat were fed in some years in the 30 dse/ha treatment. One year’s data (1995 to 1996) from the current phase, where the 10 dse/ha treatment is applied to all sites, has been added to extend the range of sown species presence for this treatment. Plots have been fertilised annually with 250 kg/ha of single superphosphate from 1963 and with 125 kg/ha of potassium chloride until 1988.

Plant species presence

Basal cover of plant species was estimated as ground level hits of plant bases per 100 points (BC%) using a vertical 10 pin frame (Levy and Madden 1933) with 800 points/plot/year. BC% was recorded in late May 1964, and in late September for all subsequent years. Sown white clover was the dominant legume in the 10
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and 20 dse/ha treatments. Annual clovers (*T. cernuum* and *T. glomeratum*) assumed dominance in the 30/ha treatment during the 1970s (Hutchinson *et al.* 1995), where they would have contributed significantly to sheep nutrition and to the soil nitrogen economy. However, with their short growing season (four to five months) their presence was weighted as 0.4 times the value of white clover presence. Applying this weighting, sown species are defined in this paper as phalaris plus total clovers.

**Wool production and calculated metabolisable energy intake (MEI)**

Mean data for annual greasy fleece weight (GFW) were standardised to 365 days. Sheep were weighed (*ca.* 42 day intervals) directly from the plots at a standard time of day to reduce variation in gut fill. Liveweight was corrected for fleece carried by partitioning annual GFW (kg/sheep) using clippings from tattooed patches or dyebanded staples. Energy notation and units follow SCA (1990). At Chiswick, there was substantial research on energy use by grazing sheep, which was based on similar sheep, pasture type and grazing conditions to this study, and hence local results were used to calculate MEI. Young and Corbett (1972) measured the maintenance energy expenditure (MEm) of groups of Merino wethers, held at near constant liveweight (45, 35 and 25 kg W), using a *14*CO$_2$ entry rate technique between February and May. Their mean data, which were adjusted for energy expended for wool, gave the equation MEm = 0.517MJ/kgW$^{0.75}$. Energy costs of grazing and maintaining body temperature were considered to be included. The metabolic cost of liveweight gain (0.1MEp) was added (Corbett *et al.* 1987), along with adjustment for sheep age and the use of equations for energy content of empty liveweight gain and loss (SCA 1990). Local data from Langlands and Holmes (1978) were used to approximate seasonal values for ME/kg feed dry matter in sown pastures at Chiswick. The values resolved and/or used for the efficiencies of energy conversion were: for maintenance (k$_m$) 0.66-0.73, for body gain (k$_g$) 0.35-0.48, and for catabolism 0.8. The final step was to deduct the metabolisable energy content of wheat eaten using converted values from Langlands (1973). MEI calculations and GFW data were adjusted to a ‘grazing only’ basis with the multiplier (1-wheat MEI/total MEI).

**Index of soil moisture stress (SMS)**

Although total and seasonal combinations of rainfall were tested as predictors, an index of SMS was superior in accounting for the effect of annual moisture conditions on sheep performance. SMS was based on the fraction of weeks in each year (October to September) when linear moisture (mm) fell below 50% of field capacity (75mm) in the 0 to 260 mm soil layer, which was considered to represent the ‘effective’ root zone for pasture growth. The water balance model used and its output have been reported (Hutchinson *et al.* 1995).

**Statistical analyses**

GFW (Y$_1$) and MEI (Y$_2$) were predicted from the variables sown species BC% (X$_1$) and SMS (X$_2$) using the model Y$_{1,2}$ = aX$_1^b$ - cX$_2$. When either coefficient ‘b’ or ‘c’ did not approach significance then the corresponding variable (X$_{1,2}$) was removed and a reduced model fitted. The Non-Lin program (Quasi-Newton) of the SYSTAT package was used for fitting the data (Wilkinson 1989). Standard descriptive statistics and the Pearson correlation were also used.

**RESULTS**

Mean GFW for the 10/ha treatment was 5.4 kg/sheep/year. For the 20 and 30 dse/ha treatments the means declined non-linearly to 5.1 and 3.3 kg/ha/year. The effect of increasing stocking rate on the declining stability of annual GFW was reflected by increase in the c.v.(%) between years with values of 9, 12 and 20% for the 10, 20 and 30/ha treatments. The trend shows an acceleration in the instability of GFW as stocking rate increased.

The annual values for calculated MEI from grazing as MJ/sheep/day also declined non-linearly with stocking rate increase: 12.2, 11.4 and 8.2 for the 10, 20 and 30 sheep/ha treatments; the stability of the values also declined as indicated by increased c.v.(%) of 5, 8 and 17%. When data were pooled across treatments and years, MEI and GFW were positively correlated with r = + 0.923 (P<0.001).

The range in sown species presence across years for the 10 dse/ha treatment was 30 to 7 BC%. This range was widened considerably by the addition of 1995-6 data from the current Phase 3 of the experiment where pastures of widely different species composition are now grazed over all plots at 10 dse/ha. Sown species presence ranged from 33 to 11 and 36 to 5 BC% for the 20 dse/ha and 30 dse/ha treatments. Fractional values for SMS (October to September) ranged from 0.02 to 0.36 with a mean value of 0.19. In the major drought (1964-5), when all sheep were removed, the value of SMS was 0.60.
Values for the fitted coefficients, which relate GFW and MEI to sown species presence and to soil moisture stress, are given in Table 1. There was no regression for the 10 dse/ha treatment indicating that loss of sown species had no significant effect on the two animal production parameters at that stocking rate. Responses to dry years (high values for SMS) were significant only at the 30/ha rate. The response curves (Figure 1) for that treatment were calculated using the mean annual value for SMS (0.19). Predicted peak values for GFW, with a full complement of sown species (32% BC and hence 68% bare ground) were 6.0 and 4.3 kg/sheep/year for the 20 and 30 dse/ha rates. For comparison, the predicted values for GFW associated with an 80% loss of sown species were 4.3 and 3.2 kg/sheep/year.

Responses for MEI and GFW to sown species loss were in general agreement. However MEI values provide information on levels of nutritional stress and its associated risk when high stocking rates are based on grazing alone. MEI responses are compared in Figure 1 with the level needed to maintain a comparable Merino wether at body condition score (CS) 3. At 10/ha a CS3 level would be supported year-long and independently of botanical status. For the 20/ha treatment, a sown species presence greater than 12% BC would provide maintenance MEI at CS3 on an annual basis. At 30/ha, grazing alone failed to support CS3 on a year-long basis at any level of sown species presence.

Table 1. Values for coefficients (with standard errors) of equations \( Y = aX^b - cX^c \) for predicting mean GFW/sheep/year (\( Y_1 \) kg) and MEI as MJ/sheep/day (\( Y_2 \)) from presence of sown species (\( X_1 \)) as BC (%) and SMS (\( X_2 \)) defined as fraction of the year under soil moisture stress.

<table>
<thead>
<tr>
<th>Sh/ha</th>
<th>GFW</th>
<th>MEI</th>
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<tbody>
<tr>
<td></td>
<td>a</td>
<td>b</td>
</tr>
<tr>
<td>10</td>
<td>5.41(0.12)</td>
<td>-</td>
</tr>
<tr>
<td>20</td>
<td>2.71(0.88)</td>
<td>0.23(0.12)</td>
</tr>
<tr>
<td>30</td>
<td>2.87(0.53)</td>
<td>0.17(0.07)</td>
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</tbody>
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* coefficients significant at 5% level; ** at 1%; *** at 0.1%

Figure 1. Curvilinear functions (Table 1) showing the effects of declining sown species presence (BC%) on mean GFW kg/sheep/year and mean MEI as MJ/sheep/day. The dotted lines define an 80% loss of sown species and the maintenance energy requirement for a Merino wether at condition score (CS) 3.
DISCUSSION

The stability and resilience of grazing systems are two important parameters which reflect their sustainability (Hutchinson 1992). Assessments of such parameters are needed at all levels of the enterprise i.e. economic, animal, plant and soil. The data reported show a consistent decline in the stability of both GFW/sheep/year and MEI/sheep/year with increased stocking rate. Values for the latter provide information on the ability of grazing sheep to harvest useful energy from the grazing resource. This enables assessment of nutritional stress and risk, the potential for compensatory gain and the need for supplementary feeding both for production and for ethical reasons. From the data in this experiment, the technical maximum production per unit land area would be represented by the 20 dse/ha treatment; however, with loss of sown species and increased need for feed supplements this stocking level would need review. Most farmers do not stock at the technical maximum but choose a lower level for reasons of risk aversion and utility (McArthur and Dillon 1971). To these reasons there must be added the cost involved in losing the sown species resource.

Loss of sown species and a sensitivity to soil moisture stress at a high stocking rate are shown to be major factors governing the level and stability of sheep performance in these well-fertilised pastures. However, there is a complex interplay of processes which determine the stability behaviour of these experimental systems over 35 years. We are currently assessing plant succession, grazed plant production and the carbon economy, the spatial distribution of nutrients and responses in soil biota. An understanding of the processes involved may provide a basis for predicting long term change in sown temperate pastures and a basis for determining the potential to manage change.

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REFERENCES


