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MODELLING A HILL-COUNTRY SHEEP PRODUCTION SYSTEM

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SUMMARY

The experimental comparison of developing hill-country systems requires regular modification of stocking rate as development progresses. A model was constructed to establish whether these decisions could be made on a more quantitative basis and to predict sheep production under set stocking from measured pasture growth rates. Apart from 1978/9 (for which the model was developed) ewe liveweights were predicted closely only in 1975/6 when the model was run from June 1975 to March 1980. Experimentation on the model indicated that further information was required to predict the effect of the animal on pasture growth rates and the organic matter digestibility of hill-country pastures.

INTRODUCTION

During pasture development in a hill-country farmlet trial in the southern Ruahine Ranges (Grant *et al.*, 1978), stocking rate was changed to maintain similar levels of animal liveweight (LW) and herbage availability across fertiliser treatments. Simulation modelling may provide a means of exploring more quantitatively the likely results of a range of stocking-rate decisions. Modelling can also help gain a closer understanding of energy flows within the system and evaluate both the experimental measurements being made and outcomes of proposed future experimentation. This paper reports our progress in modelling one of the management treatments — a high fertiliser, set-stocked ewe-lamb system. In this treatment, measured pasture production averaged 12.1 t/ha, made up of 16% legumes, 44% low-fertility tolerant grasses and 34% ryegrass and other grasses requiring high fertility. Over the experimental period winter stocking rate increased from 8.8 to 14.6 ewes/ha.

MODEL OUTLINE

Energy flow was modelled through two main-state variables; green herbage availability above ground level and LW. Mean pasture production, used as energy input to the model, was measured from cage enclosures cut on average seven times per year using a trim technique (Grant and Lambert, 1979) and weighted for slope and aspect. These data integrated environmental effects and

allowed us to explore changes occurring during pasture development without having to include fertility influences in a pasture growth compartment of the model.

Pasture senescence acted as a sink for plant material not grazed in the set-stocked pasture. Herbage death rates, as a function of time of year and standing yield, were based on maximum values recorded by Brougham (1962), Hunt and Brougham (1966) and Hunt (1970).

Animal intake was made a function of pasture availability, pasture digestibility, ewe physiological status and LW. Lamb intake prior to weaning was aimed at meeting shortfalls in energy required for LW gain targets not met by milk intake.

An animal energy balance was calculated on the same basis as those described by Vera *et al.* (1977) and Vickery and Hedges (1972) and included maintenance requirements estimated by one of us (D. A. Clark, unpublished data).

The model was formulated to simulate the system with rates of processes calculated daily from June 1978 to June 1979. After validation for this period, the model was run continuously for the period 1975-1980.

RESULTS AND DISCUSSION

Ewe and lamb LW for the validation year were predicted closely when the model was run with measured pasture availabilities, indicating the relationships included in the model described animal energetics satisfactorily. However, when pasture growth rates from cages were used to drive the model, predicted pasture availabilities from summer through to winter were greater than those measured — 2700 kg green DM/ha in January compared with 1700 measured. Cage data appeared to overestimate net pasture growth over the late spring to autumn period under set stocking.

Experiments carried out on the model derived an empirical function to multiply measured pasture growth rates and obtain the annual pattern of observed pasture availabilities, shown in Table 1. Also listed is a ratio of pasture growth rates under 2 and 4 weekly cutting, calculated from mean growth rates measured at Waimate West, Taranaki over the period 1974-79 (D. L. Buxton, pers. comm.). Apart from the timing of seasonal changes, the effect of frequent mowing on pasture growth appears to have a similar, but more extended, effect to that assumed to occur through grazing under set stocking.

The seasonal nature of the effect of set-stocking on pasture growth cannot easily be related to standing green herbage as has been done in other set-stocked (Vickery and Hedges, 1972) or rotationally grazed (Wright and Baars, 1975) pasture/animal models. At low winter grass yields (800 kg green DM/ha) growth rates under grazing were about the same as those under cages, whereas at relatively high December yields (1900 kg green DM/ha) growth rates under grazing appeared to be restricted to about 75% of those measured under cages.

Actual ewe LW measured in the field and simulated by the model with net pasture growth restricted by the empirical function listed in Table 1 are shown in Fig. 1. Gaps in measured LW reflect infrequent weighing around lambing, at which time ewe LW changes rapidly. When the model was run continuously for the 5-year period, only in the first year and the validation year did the model closely predict ewe LW. Lamb LW, buffered by milk intake, showed less variation from year to year and was predicted satisfactorily for all except the last year. In 1979 low ewe LW probably resulted in reduced milk production and therefore low lamb LW.

TABLE 1: PASTURE GROWTH RATE (GR) MULTIPLIER
INFERRED FROM MODEL AND OBSERVED RATIO
OF 2 AND 4 WEEKLY CUTTING SCHEDULES

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
GR multiplier	.75	.75	.68	.75	1.0	1.0	1.0	1.0	1.0	.93	.75	.75
2-weekly/4-weekly	.96	.80	.83	1.0	.91	.93	1.0	.76	.69	.68	.66	.82

Animal factors not included in the model, such as gut fill effects and components of maintenance, may contribute to the lack of general predictive ability of the model. However, the discrepancies between ewe LW predicted by the model and experimental observation illustrate two main areas where further information may improve the present model.

1. Pasture availability. Ewe intake is restricted by pasture availability in winter and early spring. Elaboration of a pasture growth section for the model based on plant responses to climate should correct predictions of low pasture availability in 1976 and high availability in 1979. In 1979, the effect of a cold wet spell in early spring, undetected by infrequent cage cuts, appeared to have a significant effect on ewe LW.

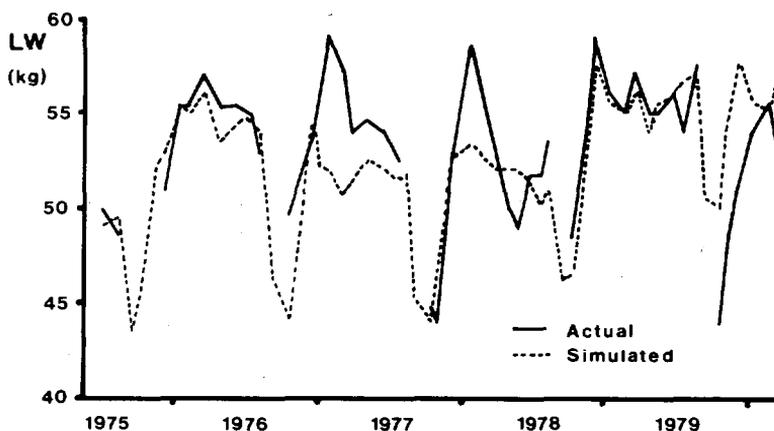


FIG. 1: Actual and simulated trends in ewe liveweights.

2. *Pasture digestibility.* Pasture digestibility limits ewe intake over the summer and early autumn. However, at present only a single digestibility function describes the annual trend. Errors will be introduced where pasture growth patterns differ from the validation year. For example, in summer 1977 and 1978 peak pasture production occurred approximately a month later with a probable later decline in digestibility. The early decline in digestibility in the model prevented the ewes attaining peak LW in February 1977 and January 1978. Similarly, a decline in both availability and digestibility during a prolonged dry spell in summer-autumn 1978 was not catered for in the present model. Further information is required to relate apparent digestibility to variation in pasture factors such as growth rate, species composition and live/dead balances.

CONCLUSIONS

Simulation modelling enabled us to evaluate the dynamics of energy flow in a set-stocked ewe-lamb system. Preliminary experimentation on the model to explore alternative stocking strategies and the direction of future investigations can be made, recognising the limitations surrounding the net pasture growth and digestibility sections of the model. However, the usefulness will be improved when answers are found to questions raised during construction and operation of the model.

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