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Stocking rate effects in dairying

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ABSTRACT

A simple stocking rate model was used to derive stocking rates that maximise milkfat/ha and profit/ha. A study of recent changes in the cost/price structure indicates that economically optimal stocking rates are determined mainly by the parameters of the milkfat/cow-stocking rate relationship and are relatively insensitive to even large changes in the cost/price structure. Farmers' options of holding costs and adjusting stocking rates are discussed. Finally, an example is used to demonstrate the use of the method with research data and to illustrate factors worth considering in designing and interpreting trials to assess the value of a management input. Future trials should be run at stocking rates designed to describe production-stocking rate relationships rather than to accentuate treatment differences.

Keywords Stocking rate relationships; milkfat/cow; milkfat/ha; profit/ha; optimal stocking rate

INTRODUCTION

The dominating effect of stocking rate (SR) in grassland farming has often been described. Once the decision to graze livestock has been made, the choice of SR becomes the most basic question to be answered. The aim of this paper is to improve the understanding of the effect of SR on production and profitability. A simple linear model relating performance per animal to SR is used. Although the material is presented in the context of seasonal milkfat production, the concepts can be applied to other grazing enterprises. The effect of SR on reproduction, animal and farmer health, labour costs and other sociological factors are not considered, even though it is acknowledged that these might sometimes be more important than production economics in assessing the effects of SR.

The Stocking Rate Model

Theoretical models which describe the relationship between animal performance in a grazing system and SR have been proposed by several researchers. In essence all the models express the fact that if SR is the only variable, performance per animal is unaffected over a range of low SRs and then falls progressively with increasing SR beyond a critical value. The simplest mathematical expression of this phenomenon was given by Jones and Sandland (1974), viz,

$$\text{Milkfat/cow} = k \quad \text{for } S \leq S_c$$
$$\text{Milkfat/cow} = a - bS \text{ for } S \geq S_c (b > o), \qquad (1)$$

where S = Stocking rate (cows/ha), S_c is the critical SR, k is constant, and a and b are the constants in a linear equation. This relationship is expressed diagrammatically in Fig. 1(a). The relationship is widely used when production is measured in liveweight gain (Jones and Sandland, 1974). Very few dairy trials have had enough SRs to enable validation of the model. Although the exact mathematical form of the decline over the range D-E is debatable, the important point is that a linear relationship is likely to be a good approximation (King and Stockdale, 1980).

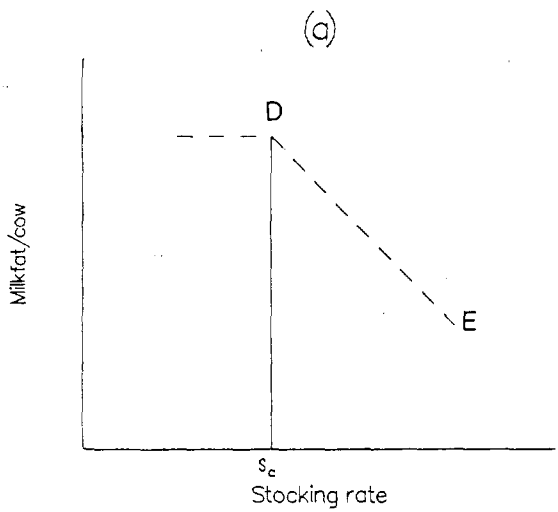
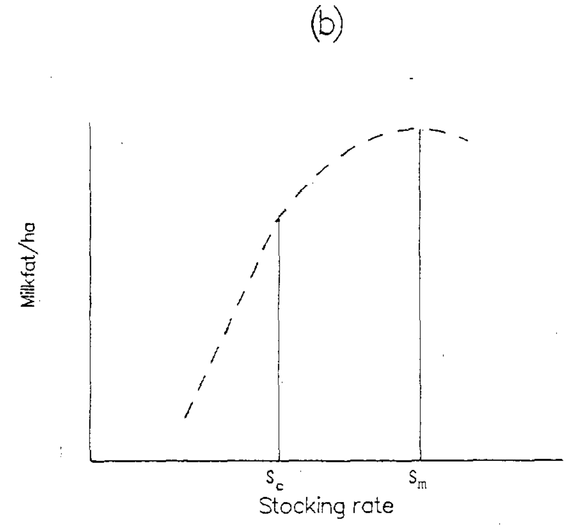


FIG. 1 Relation between SR and (a) milkfat/cow. (b) milkfat/ha.

Given that this negative linear relationship is appropriate, the following properties of the relationship between milkfat/ha and SR can be inferred and are illustrated in Fig. 1(b):

$$\text{Milkfat/ha} = aS - bS^2, S \geq S_c \qquad (2)$$



The SR which maximises milkfat/ha is:

$$S_m = a/2b \tag{3}$$

In an attempt to estimate a and b, Holmes and Macmillan (1982) pooled data from SR trials in New Zealand to obtain the values a = 220 and b = 21, from which it follows that milkfat/ha is maximised at a SR of slightly in excess of 5 cows/ha. These authors pointed out that since data from different trials had been pooled, the estimates should be treated with some caution. If an allowance for 20% replacement stock is made, S_m reduces to about 4 cows/ha.

Profitable Stocking Rates

In order to investigate the question of what constitutes a profitable SR, the following cost model will be assumed:

$$\text{Costs/ha} = CS + H$$

where C represents costs/cow and H represents costs/ha which are independent of SR. Costs/cow include replacement cows, less the sale of culls, at an assumed replacement rate of 20%. Then, if P is the price of milkfat/kg, net-income/ha = P × milkfat/ha — (CS + H). The SR which maximises net-income/ha will obviously not depend on the value of H and therefore, it will also maximise gross margin/ha, which we define as P × milkfat/ha — CS. The substitution of (2) for milkfat/ha, together with some mathematics, gives the optimal SR, S_o, as:

$$S_o = S_m - R/2b, \tag{4}$$

where:

$$R = C/P = \frac{\text{Costs/cow}}{\text{Price of milkfat.}}$$

The use of this methodology for determining economically optimal SRs was presented by Hildreth and Riewe (1963).

In a production system S_o is always between S_c and S_m. As R increases (costs high in relation to price), S_o decreases towards S_c and per head production will be higher. If R decreases, S_o will increase towards S_m — more animals with a lower per head production. Fig. 2(a) illustrates trends over the last decade in costs (C) and prices (P). Their ratio R and hence S_o, derived using the production estimates of Holmes and Macmillan (1982), are given in Fig. 2(b).

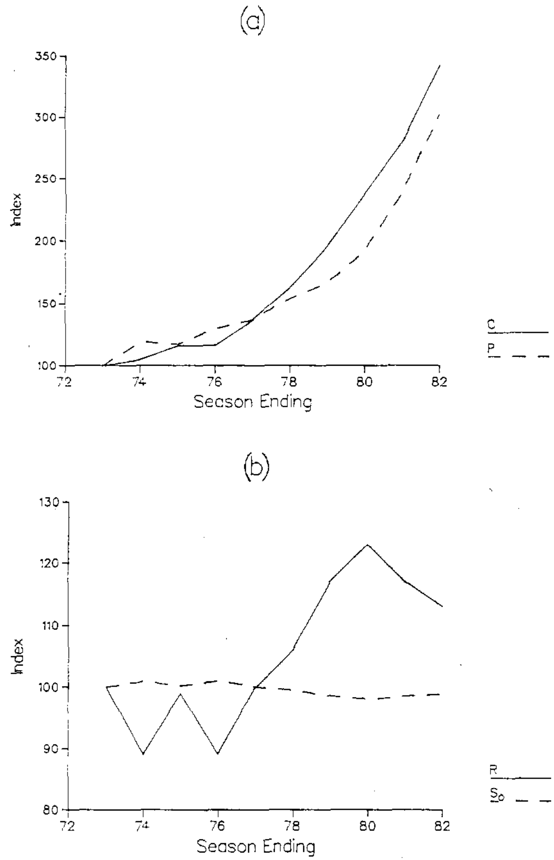


FIG. 2 Recent trends (1972/3 figures taken as 100) in
(a) C and P, and
(b) R and S_o.

It is evident from Fig. 2(b) that, although the cost-price ratio increased steadily from 1975/6 to 1979/80 and then declined, these changes had minimal effect on S_o. However, it is not implied that such changes in R did not markedly influence the gross margin. In practice, optimal SRs are determined largely by the biological parameters a and b.

Currently we believe that R is in the range 30 to 50.

Using S_m = 5 and b = 21 (Holmes and Macmillan, 1982) and this range in R, current optimal SRs of 3.75 to 4.25 cows/ha are derived (3.25 to 3.75 if allowances for carried replacements are made). Although trends can be measured with confidence, it is difficult to assess all costs truly associated with SR, so the above values of R and S_o should be considered as tentative.

In order to improve his gross margin, a farmer should manipulate the variables over which he has greatest control, viz, costs/cow and SR. For this reason it is interesting to investigate iso-gross margin curves for combinations of SR and costs/cow. An example is given in Fig. 3.

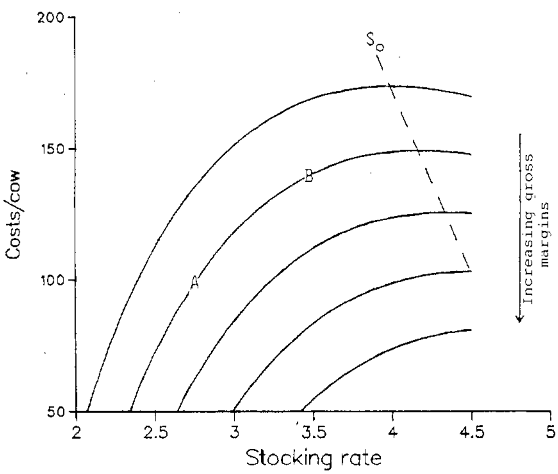


FIG. 3 Gross margin contours for P = \$3.30, a = 220, b = 21.

A farmer can progress from one iso-margin either by increasing SR or by reducing costs/cow or through some combination of both. It is clear that low cost and low SR farmers at position A can make better economic progress by increasing SR, whereas farmers at position B would do better by attempting to reduce costs. The broken line gives optimal SRs for given costs/cow.

Use of the Models in Analysing Trial Data

In this section the effect of changing the production parameters, viz a and b, on gross margins, will be examined. The example concerns the insecticidal control of grass grub at the Taranaki Research Station, Normanby. The analysis below is not intended to be definitive as data from only one year are available and no account will be taken of pasture production and grass grub densities. The results for 1981/2 (N. A. Thomson, pers. comm.) are given in Table 1.

Estimating a and b for each system in equation (1) leads to the relationships between SR and milkfat/ha in Fig. 4(a). In Fig. 4(b) the relationships between gross margin and SR are illustrated. These gross margins are based on (i) P = \$3.63; (ii) C = \$100; (iii) insecticidal costs of \$100/ha.

TABLE 1 Milkfat production per cow (kg).

	Stocking rate cows/ha	
	3.7	4.3
Untreated	151	124
Insecticide	149	133

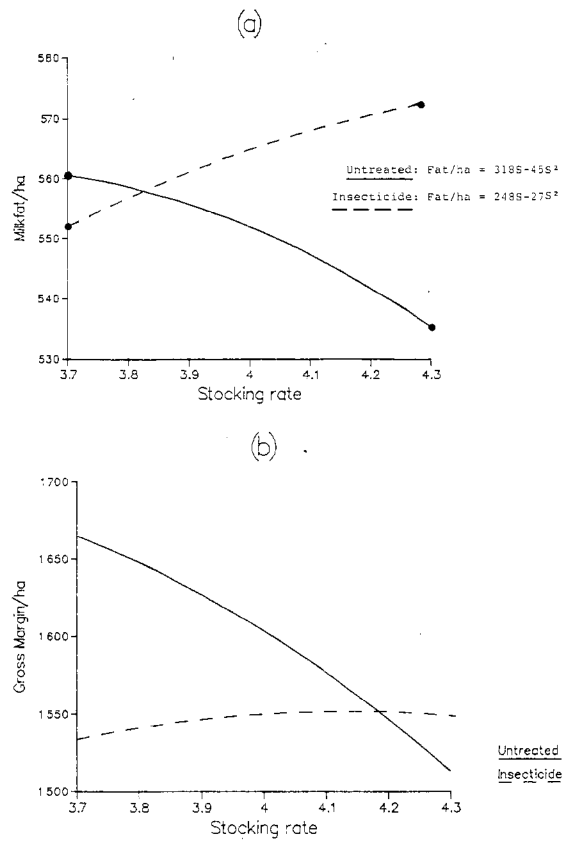


FIG. 4 Relation between SR and (a) milkfat/ha, (b) gross margins/ha.

The SRs which maximise per-hectare production are estimated as 3.5 and 4.6 for the untreated and insecticidal farmlets respectively. In hindsight these estimates would suggest that for the 1981/2 season the untreated farmlets should have run at slightly lower SRs and the insecticidal farmlets at slightly higher ones.

The difficulty of generalising results from a trial conducted at a single stocking rate are clearly demonstrated by Fig. 4(a). Furthermore, Fig. 4(b) demonstrates the difference between systems with 'high' and 'low' b-values. A low b-value means that the gross margin is not sensitive to the choice of SR, whereas the choice of SR is more critical when the b-value is high.

Other management options such as fertiliser, calving date, conservation and cow quality could be assessed in the manner described above. However, a study of dairy trials in New Zealand, which include SR as a factor, would suggest that production-SR relationships have not been well determined. The comparison of treatments would be enhanced if the SRs for each treatment were chosen so that the response curves for production/ha and net-income/ha could be well estimated. Treatments could then be compared over a range of SRs including those which maximise production and profit.

ACKNOWLEDGEMENT

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