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A MODEL FOR ANALYSING ALTERNATIVE FEEDING STRATEGIES DURING THE LACTATION CYCLE

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SUMMARY

A modelling approach is developed to analyse productive performance of cows at different stages of the lactation cycle. The model accounts for changes in both condition score and milk production, thus allowing a true comparison of nutritional and economic efficiency criteria for alternative feeding strategies during the lactation cycle.

The analysis of data from nutrition studies is presented. Results indicate that marginal efficiency of pasture dry matter (DM) conversion to milk, adjusted for condition score changes, are higher for extra DM fed post-calving compared with the same additional DM fed pre-calving.

INTRODUCTION

Dairyfarmers are continually faced with the problem of deciding what is the optimum level of feeding for their cows. Evaluation of alternative feeding strategies for dairy cows requires estimation of production responses to different feeding levels at different stages of the lactation cycle.

A modelling approach is developed to analyse productive performance of cows at different stages of lactation. The analysis of data from a nutrition study is presented.

METHOD

A balance equation for the cow at any particular stage of the lactation cycle can be written:

Energy in = (milk + body tissue change + maintenance) Energy + Energy losses.

Estimating this single equation for example in the form

$$\text{Feed Energy}_t = f(\text{FCM}, \Delta W, W^{0.75})_t + e_t \qquad \text{Model 1}$$

where t = t th stage of lactation

FCM = fat corrected milk

ΔW = body tissue change

$W^{0.75}$ = metabolic liveweight

e = error term

does not enable us to predict the distribution of energy between performance functions. It is this uncertainty regarding distribution of energy between milk and body tissue that is referred to by Moe and Tyrrell (1975) as the "partition problem".

In this paper we are concerned with the estimation and interpretation of productive relationships for lactating dairy cows to take account of the "partition problem".

Model 1 can be decomposed into 3 equations

$$\begin{aligned} \text{FCM} &= f_1(W^{0.75}, \text{feed energy}) + e_1 && (1.1)\\ \Delta W &= f_2(W^{0.75}, \text{feed energy}) + e_2 && (1.2)\\ e_1 &= f_3(e_2) && (1.3) \end{aligned}$$

Equation (1.3) links equations (1.1) and (1.2) and in part captures differences in genetic ability between animals and in part the effect of differences in nutritional history between animals. Nutritional history is also captured in part by the value for $W^{0.75}$. The model could be expanded to include a more explicit statement of nutritional history.

In Model 2, productive relationships have been divided into controlled and uncontrolled relationships. Equations (1.1) and (1.2) predict the expected values for FCM and ΔW given values for ($W^{0.75}$ and feed energy). Equation (1.3) describes the relationship between FCM and ΔW that is currently not under management control, though previous control (nutritional history) may be partly responsible for the observed values of the errors. Equation (1.3) cannot be interpreted as a causal relationship; it simply states that there is a relationship between the errors of equations (1.1) and (1.2).

Models 1 and 2 are equivalent in the sense that Model 1 can be derived from Model 2, but not vice versa. We have chosen to focus our attention on Model 2 because it enables us to estimate performance response to different feeding levels at different stages in lactation.

Model 1 would be useful if we wished to estimate energy intake associated with different observed levels of the performance variables.

Some of the difficulties involved in using a modelling approach include choice of variables to use in the model (e.g. age, breed, liveweight) and the functional form of the equations (e.g. linear, curvilinear). These problems could be overcome with sufficient data on which to develop and test goodness of fit questions.

The present paper provides a framework for analysis of feeding strategy questions based on preliminary estimates of a version of Model 2.

A specific application of the model is outlined using data from nutrition experiments carried out at the Dairy Research Institute, Ellinbank, Victoria.

Two hundred cows were involved in these experiments, the two treatments were condition score at calving (range 3 to 6) and feeding level in the first five weeks of lactation (range 7-15 kg DM/cow/d). All cows were commonly grazed in any particular year from weeks 6-20 of lactation (Grainger, 1980).

If we are to make comparisons based on physical performance parameters then we must recognise difficulties when treatment differences show up in more than one variable e.g. milkfat yield and condition score changes (Grainger, 1980).

We can attempt to handle this problem in a complete systems model where final performance criteria are economic rather than physical. For the sake of simplicity we have balanced condition score at some point post 20 weeks, therefore the only performance difference resulting from the treatments is milkfat yield.

RESULTS AND DISCUSSION

The following equations were estimated from the Ellinbank data.

$$FY_{0\text{-}20} = 65.11 - 0.62DMI + 1.49CS + 0.67CS{*}DMI \qquad R^2 = 0.40$$

$$CS_{0\text{-}20} = 2.27 + 0.10DMI - 0.48CS - 0.02CS{*}DMI \qquad R^2 = 0.63$$

where $FY_{0\text{-}20}$ = cumulative milkfat yield (kg), 0-20 weeks of lactation

$CS_{0\text{-}20}$ = change in condition score, 0-20 weeks of lactation

CS = condition score at calving

DMI = dry matter intake (kg DM/cow/d), 0-5 weeks of lactation

The differential partitioning of energy between milkfat and condition score change can be assessed given different values of CS and DMI (Fig 1).

The response in terms of milkfat yield to CS is greater at higher DMI and the response to DMI is greater at higher CS. Cows with a CS $>$ 5 lose condition after calving, more so at higher DMI.

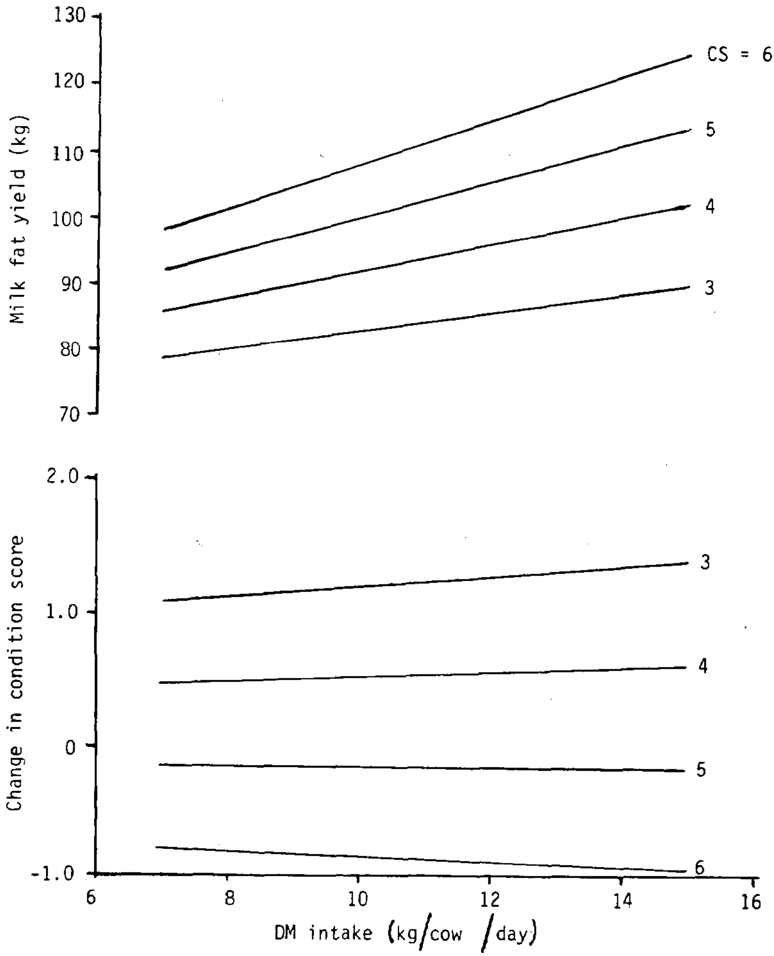

FIG. 1: *Response of the cow (0-20 weeks of lactation) to condition score at calving and feeding level in weeks 0-5 of lactation.*

In order to provide further illustration of the model, it has been used to assess two alternative strategies: given some additional quantity of DM over some base level of feeding (represented by CS at calving and base DMI), what are the predicted differences in production from increasing CS at calving versus increasing DMI post calving, (stategies B and A respectively). If we could, we would apologise to Stephen Leacock for omitting poor old C.

TABLE 1: OUTCOME OF FEEDING 150 KG DM EITHER BEFORE (B) OR AFTER CALVING (A) AT DIFFERENT BASE DM INTAKES (0-5 WEEKS), GIVEN A BASE CONDITION SCORE (CS) OF 3.50

Treatment	*CS at calving*	*DM intake (0-5 weeks) (kg/cow/d)*	*CS at 20 weeks*	*Cumulative milkfat yield (FY) (0-20 weeks) (kg)*	FY_A-FY_B
B	3.94	7.0	4.45	85.2	2.0
A	3.50	9.8	4.36	87.2	
B	4.00	9.0	4.50	89.7	2.0
A	3.50	12.3	4.43	91.7	
B	4.05	11.0	4.55	94.3	1.8
A	3.50	14.9	4.50	96.1	

Table 1 represents the predicted results for a base CS = 3.5 and three base DMI values (7, 9, 11) for an additional 150 kg DM/cow and a common CS = 4.55 at some time after 20 weeks. Thus a cow not reaching CS = 4.55 by the end of week 20 will have available less than 150 kg DM for consumption either before calving (to increase CS) or after calving (to increase DMI). All treatments utilise an additional 150 kg DM and have the same eventual CS.

Table 2 presents the predicted results for a base CS = 5.5 and an eventual CS = 5.25. For the pre-calving and post-20 week periods, one condition score has been assumed to require 272 kg DM/cow.

Tables 1 and 2 are not strictly comparable because cows have different base condition scores (at calving and post-20 weeks) and would probably in practice represent different stocking rates. Feeding extra dry matter after, rather than before calving, resulted in a greater milkfat yield, the advantage being greater at higher base condition scores and at lower base DMI. These results represent a nutritional view of one aspect of the feeding management of

TABLE 2: OUTCOME OF FEEDING 150 KG DM EITHER BEFORE (B) OR AFTER CALVING (A) AT DIFFERENT BASE DM INTAKES (0-5 WEEKS), GIVEN A BASE CONDITION SCORE (CS) OF 5.50

Treatment	*CS at calving*	*DM intake (0-5 weeks) (kg/cow/d)*	*CS at 20 weeks*	*Cumulative milkfat yield (FY) (0-20 weeks) (kg)*	FY_A-FY_B
B	6.03	7.0	5.23	98.1	3.9
A	5.50	9.3	5.00	102.0	
B	5.96	9.0	5.15	104.5	3.2
A	5.50	11.1	4.97	107.6	
B	5.89	11.0	5.09	110.7	2.5
A	5.50	13.0	4.95	113.2	

dairy cows. Other factors, e.g. cost of feed production and efficiency of feed utilisation, need to be considered before applying these conclusions to the farm situation.

REFERENCES

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