A PROFIT-MAXIMISING BEEF CATTLE FINISHING MODEL

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SUMMARY

The structure and equations constituting a beef cattle finishing model that runs on a micro-computer are described. The inputs required are unit costs and characteristics of available feedstuffs, number and characteristics of the cattle, target carcass characteristics and use of a growth promotant and/or fermentation modifier.

The program estimates, for an ad libitum feeding system, the target liveweight, growth rate, period on feed, conversion efficiency, the total quantities of each feedstuff required, total feed cost, peak daily throughput of each ingredient, and the composition of the least-cost diets, over the range 9-11.25 MJME/kg DM. (Keywords: Model, cattle, finishing)

INTRODUCTION

As a consequence of seasonal pasture growth and thus feed availability and quality, in most of Australia it is only feasible to finish cattle to premium-priced market specifications off pasture alone for about half the year. In order to maintain continuity of supply for the high-quality table-beef market strategic feeding is necessary, and for this purpose a range of feedstuffs varying widely in quality, availability and cost (amongst materials and locations, and over time) may be employed. Optimising the use of such feedstuffs in diets for seasonal finishing involves complex calculations to generate diets of satisfactory quality most economically and a trade-off of quality and unit cost against efficiency of utilization by cattle which may differ in breed, age, sex and condition. The model described in this paper estimates the total quantities and costs of feedstuffs required and target performance parameters to finish cattle of given specifications at maximum profit. It is written in Pascal using the Turbo Pascal compiler and can be run on microcomputers supporting CP/M 80, CP/M 86, MS-DOS or PC-DOS operating systems.

STRUCTURE OF THE MODEL

The model was developed from reported experimental results, and includes most of the factors affecting cattle feeding enterprises. It directly estimates their marginal effects upon growth rate and feed conversion ratio in order to estimate the costs and inputs required for different options. It also assumes that extraneous influences such as infectious disease, mineral or vitamin deficiency, parasitism and competition have been avoided by appropriate vaccination, treatments, feeding space, shade and water, and that the cattle are fed ad libitum.

The model consists of four stages carried out sequentially. Each is run at specified dietary metabolisable energy concentrations (MED) through the range 9-11.25 MJME/kg DM.

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Stage 1 - Estimation of total dietary DM required

The inputs required for this procedure are the number (N) of animals, their initial paddock liveweight (ILW), final (target) carcass weight (FCW = hot wt -3%, fats out, tail off), initial (IFS = 1 to 2) and final (FFS = 3 to 4) fat scores, sex (SEX = 1 for bulls, 2 for steers, 2.5 for heifers) and age (AGE = 1 or 2 years old), the potential growth rate (PGR = kg/d) for a 1 year old steer at fat score 2 of the type to be fed, given unlimited nutrition, and the use of a growth promotant (GP = 0 or 1) and fermentation modifier (FM = 0 or 1). From these inputs, the following are estimated:
Initial carcass weight (ICW) = 0.51*ILW - 14 (McIntyre and Ryan 1982).
Carcass weight gain (CWG) = FCW-ICW.
The standard carcass weight (SCW), for early-maturing cattle of the age, final fat score and sex specified, = (64*AGE + 30*FFS -32)*(1.3-0.15*SEX) (Klosterman and Parker 1976; Ntunde et al 1977; Bouton et al 1982; May et al 1986).
A Maturity Type Index (MTI) for the cattle to be fed = FCW-SCW. This index is the difference in carcass weight at a given age, fat score and sex between the cattle to be fed and a standard (early maturing) type.
Dietary DM required per unit carcass weight gain (DMCRC), at each MED, =
10.5* [1-0.067*(MED-11.25)] (May and Barker 1983; MAFF 1984)
 * [1-0.078*GP](Brown 1970)
 * [1-0.08*FM](e.g. Berger et al 1981; MacGregor 1983)
 * [1+0.065*(IFS-2)](Barker et al 1985)
 * [1+0.10*(FFS-3)](May et al 1986)
 * [1+0.0028*MTI](May et al 1986)
 * [1-0.374*(PGR-1.3)](May et al 1986)
 * [1+0.253*(AGE-1)](May et al 1986)
 * [1+0.05*(SEX-2)](Klosterman and Parker 1976; Galbraith and Topps 1981)
Total dietary DM required (TDM), at each MED, = CWG*DMCRC*N

Stage 2 - Estimation of composition of diets incurring least cost per tonne DM

The inputs required for this are, for each available feedstuff, any constraints on availability or its concentration in the dietary DM (DDM), its total (landed, storage, processing and feeding) cost per tonne (TCTF), DM content (FDMC), MED, crude protein (CP) and long fibre (LF) content in the DM, and, for each dietary MED, the TDM. LF is the crude fibre (CF) of those feedstuffs fed as particles of more than 1 cm length, i.e. coarsely milled roughages.

The fractional composition (FDM) and cost per tonne DM (CTDM) of the cheapest diet at each dietary MED specified are estimated using the GULP linear programme of Pannell (1985). The objective function is the minimum cost per tonne DDM subject to equality constraints for MED, minerals, FM and bulk (1 tonne DDM), minimal constraints for CP and LF in the DDM and any constraints on feedstuffs as fractions of the DDM. The output of the LP also includes shadow prices and costs, and range analysis.

Stage 3 - Estimation of total cost and composition of diets

Total diet cost (TDC), at each MED, = TDM*CTDM.
The profit maximising diet is then determined by comparing the TDC's incurred over the range 9 to 11.25 MJME/kg DM.

At each MED specified the following are also estimated:
The total quantity of each feedstuff required (TFWM) = FDM*TDM/FDMC
The composition of each diet on a wet matter basis (FWM) = FDM/FDMC.
The dry matter content of each diet (DDMC) = ΣFDM/ΣFWM.

Stage 4 - Estimation of performance targets and management data

These are estimated, using:

Final (target) liveweight (FLW) = 1.75*FCW+27.5 (McIntyre & Ryan, 1982).

Expected growth rate (GR), at each MED, =

PGR * 1 + 0.29*(MED-11.25) (May and Barker unpublished data)
*** 1 - 0.14*(IFS-2) (Barker et al 1985)**
*** 1 + 0.10*GP (Brown 1970)**
*** 1 + 0.16*(AGE-1) (May et al 1986)**
*** 1 - 0.10*(FFS-3) (May et al 1986)**
*** 1 - 0.10*(SEX-2) (Klosterman and Parker 1976; Galbraith and Topps 1981)**

Days on feed (DOF), at each MED, = (FLW-ILW)/GR

Maximum daily diet throughput (MDD), at each MED, = 0.03*FLW*N/DDMC

Maximum daily throughput of each feedstuff (MDF), at each MED, = MDD*DDMC*FDM/FDMC.

DISCUSSION

Linear programmes have to date been mainly used in cattle feeding to generate solutions in terms of least cost per unit weight of the diet of a given quality. The model described uses solutions of this type in conjunction with performance responses to compare both the profitability and management inputs required for different quality diets. By estimating the effects of using diets of differing MED in consecutive runs and printing the output of each, the sensitivity of all the outputs to changes in MED is estimated, facilitating appropriate trade-offs between profit and other management considerations according to individual farmers' wishes.

Most differences in growth and conversion efficiency in cattle are a consequence of differences in intake of nutrients, in size, and in body composition. They are effected through differences in the maintenance requirements of the system relative to the production achieved, and in the energy cost of differences in fat content of the tissues produced. Each factor included in the model has specific effects upon these processes, which result in turn in specific effects upon growth and feed conversion. These effects can be quantified in terms of input and output, without all the intermediate processes, and in the interest of conciseness this is the approach used.

Different breeds and strains of cattle are defined in terms of their PGR, and their ILW, IFS, FCW and FFS for their sex and age, in this model. These definitions are more biologically and economically meaningful than the breed label, which includes considerable variation in these characteristics.

Feed quality is defined in terms of MED, CP, LF and DM content. The model is suggested for formulating diets of MED 9-11.25 MJ/kg because below this growth is too slow to permit finishing in young cattle (MAFF 1984), and the risks of laminitis and rumenitis are minimised by the upper limit of 11.25 MJ MED and by the LF constraint. Within this range linear functions are used to predict GR and DMCR, given ad libitum access to the diet. CP is an adequate definition of protein content in finishing diets because the range in diet digestibilities is narrow, and the degradability of the protein is of little significance in such diets (Barker et al 1985). LF is included rather than CF, because it better describes the level of effective roughage.

The model includes typical responses to zeranol, monensin and castration. Different responses to other products or to partial castration can be included by entering fractional values for them (e.g. GP = 1.2, SEX = 1.5) which reflect their effects relative to those assumed. The factors included in the model have been ascribed multiplicative rather than additive effects because, in general, growth and production responses to one factor are greatest when others are least limiting.

The output of the model will be tested against a range of production systems as a check on validity. Coefficients used in the model may require future adjustment because there has been limited research evaluating the effects of each of the factors independently of all the others. In particular, many feeding experiments have been conducted on a time-constant or weight-constant basis, which nearly always resulted in cattle on different treatments being slaughtered at different levels of fatness. Further development of the model will include incorporation of all other costs and returns into a cash budget, and analyses of the sensitivity of the output to changes in the assumed values.

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