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Factors affecting beef finishing efficiency on pasture

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ABSTRACT

A model quantifying outputs of carcass from pasture inputs was used to study factors affecting biological efficiency (BE) of finishing beef from 6 months to slaughter.

Two factors which determined biological efficiency (BE, kg carcass gain/ha/yr) on pasture were pasture utilisation and animal conversion efficiency. Effects of stocking rate, length of finishing period (1 v 2 years), mature size and maintenance efficiency of beasts on BE and its components were studied.

Stocking rate was the major factor affecting pasture utilisation rate however more lighter (eg. 12% more 750 kg than 900 kg mature sized) cattle need to be run to achieve equivalent pasture utilisation. Nine percent less cattle can be run in a 2 year system.

Average conversion efficiency was 40% lower from finishing at 2 years than 1 year. An increase in mature size from 750 to 900 kg increased animal conversion by 14%. A 20% decrease in maintenance requirements increased animal conversion by 10%.

Constraints to produce specified carcass weights further favoured BE with high mature weight beasts, particularly at intermediate carcass weights (250 kg).

Breeding cattle for high mature size appears the best way of improving the cattle available for finishing.

Keywords Beef, finishing, animal conversion, biological efficiency, pasture utilisation, mature size, model.

INTRODUCTION

In a simple grazing system the biological efficiency (BE) of beef finishing is determined by the weight of carcass gain from an area of land over a year. This depends on the amount of feed required to produce a kilogram of carcass and the percentage of annual pasture production which is consumed. The biological efficiency of beef finishing under grazing can therefore be expressed as:

Biological efficiency	= f[Animal conversion efficiency, Pasture utilisation]
(kg carcass gain/ha/yr) =	(kg feed/kg carcass gain) , (kg feed eaten/ha/yr)

Computer models which integrate basic information on cattle growth, net pasture production and pasture utilisation can be used to assess the importance of factors which affect BE. Knowledge of the relative importance of these factors is required to focus research and management strategies to improve beef finishing efficiency.

In this paper we used a model to study the effects of stocking rate, age at slaughter, mature size and maintenance requirements on BE and its components for beef finishing on pasture. The paper concentrates on the practical consequences of relationships represented in the model.

MODEL

The model simulates daily liveweight growth of cattle from weaning to slaughter on one hectare of land. It consists of 5 basic components. The relationships used are shown graphically in Figure 1.

1. Potential net pasture production (maximum possible at each site) is expressed as kg DM/ha/day for each month of the year. Actual net pasture production is modified by average pasture mass on the farm (Bircham and Hodgson (1983) data (Fig. 1a)).

2. Daily pasture intake per animal is derived from potential intake and is dependent on average pasture mass (McCall unpub. data) (Fig. 1a). Intake may be

restricted below this level by user controlled seasonal constraints on daily intake.

3. Potential intake (kg DM/hd) is determined as a function of animal age using mature weight scaling (Taylor 1980). An example of potential intake as a function of age is shown in Figure 1b. This approach allows compensatory growth to be determined on this basis of maturity/age relationships rather than liveweight relationships.

4. Maintenance energy requirements were related to degree of maturity (liveweight/mature liveweight; m) and mature weight (A) (Taylor 1982). The equation was: maint = $0.7mA^{0.73}$ (Fig. 1c).

5. The efficiency of ME use for liveweight change was also related to maturity of the animal (Taylor 1982) and Taylor *et al.* (1986) (Fig. 1d).

Carcass weight was predicted using dressing percent (D0%) data supplied by A.H. Kirton (*pers. comm.*): D0% = 0.41 + 0.000208 LW.

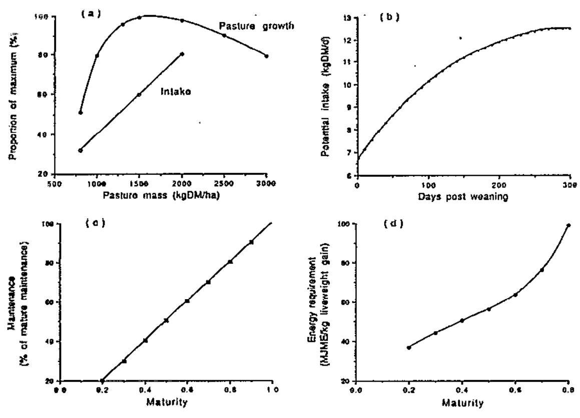

FIG 1 Graphical presentation of major components of the model: a) relative pasture growth and intake dependent on pasture mass (kg DM/ha); b) potential intake as a function of age for a 900 kg mature weight beast; c) maintenance requirements as a percent of mature weight maintenance; d) ME required in addition to maintenance for a kilogram of liveweight gain.

EXPERIMENTAL

Initial conditions specified for model experiments were a starting pasture cover of 1600 kg DM/ha on 1 April and an initial weaner liveweight of 200 kg. Potential pasture production figures used were 39.3, 23.8, 28.7, 16.1, 12.8, 8.3, 9.5, 16.7, 35.2, 50.5, 49.6, 42.7 kg DM/ha/d for January through December respectively (annual production of 10,000 kg DM/ha).

A routine devised by Nelder and Mead (1965) was used to optimise intake restrictions in each season to maximise carcass weight. Two sale times chosen were end of January and end of March. Numbers sold at each date were part of the optimisation. The model was constrained so that end pasture mass did not drop below starting mass. Pasture quality was assumed to be maintained by removing all pasture dry matter above 2000 kg DM/ha from October through December. The experimental conditions ensured a common level of management for each treatment (i.e. optimum management).

Simulations included effects of age at slaughter (1 versus 2 years of finishing), stocking rate (1.5, 2.5, 3.5, 4.5 and 5.5 beasts/ha) and contrasting mature liveweights (750 kg and 900 kg). These equate approximately to an Angus x Hereford steer and a Friesian bull, respectively. Finally, a decrease in maintenance requirements of 20% was studied to compare its effect with a 20% increase in mature weight, i.e. from 750 to 900 kg.

RESULTS

Animal Conversion Efficiency (kg DM/kg carcass gain)

TABLE 1 Animal conversion efficiency for 900 kg mature size cattle in 1 year of finishing.

Stocking rate (beasts/ha)*	kg Feed eaten /kg carcass gain	Carcass gain (kg/ha)	Carcass weight (kg/beast)
1.5	15.5	300	290
2.5	15.5	462	275
3.5	15.5	572	253
4.5	15.6	625	229
5.5	16.3	612	201

* Pasture production: 10,000 kg DM/ha/yr.

The amount of feed required per kg carcass gain (15.5) was remarkably similar across a wide range of stocking rates (Table 1) despite cattle having quite different patterns of growth and average feeding levels (as shown by differences in carcass weight).

Only at the very high stocking rate did conversion efficiency decline slightly (16.3) (Table 1). Since the amount of feed required per kg carcass gain was relatively constant across stocking rates, effects of other variables on animal conversion efficiency are presented at a stocking rate of 3.5 beasts/ha.

A decrease in mature weight of beasts from 900 to 750 kg increased the amount of feed required per kg carcass gain by about 14% in both 1 and 2 year finishing systems (Table 2). Finishing over 2 years increased feed requirements by about 40% compared to 1 year finishing.

Finally, a reduction of 20% in the maintenance requirements of a beast reduced feed required by about 10% for a 1 year finishing system (Table 2).

TABLE 2 Effect of factors other than stocking rate on animal conversion efficiency (kg DM/kg carcass gain).

	Mature Weight (kg) 900	750
Finishing period (years)		
1	15.5	17.7
2	21.8	25.5
Maintenance requirements		
Normal	15.5	17.7
-20%	14.1	15.9

Pasture Utilisation

Stocking rate was the major factor affecting pasture utilisation rate. The effect of annual pasture allowance on pasture utilisation is shown in Table 3. These results are for 900 kg mature liveweight cattle on a 1 year finishing system. While results in Table 3 relate to one pattern of potential pasture production, simulations with other patterns showed little variability from Table 3 provided management was optimised to give maximum cattle liveweights at slaughter. Close to 100% of potential production was used at an allowance of 1820 kg DM/beast/year. This was based on net pasture production with no pasture losses due to trampling during grazing.

TABLE 3 Effect of stocking rate (annual pasture allowance) on pasture utilisation for 900 kg mature size cattle on 1 year of finishing.

Stocking rate (beasts/ha)*	Pasture allowance (kg DM/beast/year)	Pasture utilisation (% of potential production)
1.5	6665	46.3
2.5	4000	71.4
3.5	2860	88.7
4.5	2220	97.7
5.5	1820	99.5

* Potential pasture production: 10,000 kg DM/ha.

Increased maintenance requirement of the beast had no effect on pasture utilisation since potential intake was related to beast age in the model. Small mature size (750 kg) beasts had a lower level of pasture utilisation at any stocking rate than the large mature size beasts and common levels of pasture utilisation could be achieved by running a 12% higher stocking rate of the "750 kg" beasts. Equivalent pasture utilisation between 1 and 2 year systems require 9% fewer beasts/ha to be run in 2 year compared to 1 year systems.

Annual Carcass Gain per Ha

Greatest carcass gains per ha were achieved at high levels of pasture utilisation since animal conversion was relatively constant across a range of stocking rates (Table 1). Where stocking rate was adjusted for each cattle type to give a common level of pasture utilisation then carcass gain per ha depended only on animal conversion efficiency. Under these conditions "900 kg" cattle had 14% higher carcass gain per ha than "750 kg" mature size beasts. One year systems yield 40% more carcass than 2 year and a 20% decrease in maintenance requirements increased carcass gain per ha by 10%.

Effect of Carcass Weight Constraints on Carcass Gain Efficiency

The results in Table 1 show that maximum carcass gain per hectare will be achieved at high levels of pasture utilisation but low carcass weights. To achieve acceptable carcass weights within time constraints some reduction from the biological optimum will be required.

As desired carcass weight increases a loss in biological efficiency will occur in 1 year finishing owing to the reduced pasture utilisation levels. At some point the carcass gain/ha will equate to that achieved from 2 year finishing with higher pasture utilisation.

The final analysis was done to look at advantages in carcass gain per ha from large compared to small mature size beasts over a range of target carcass weights. Results presented in Table 4 are for the system (1 or 2 year finishing) which gives the greatest carcass gain per ha for each carcass weight. The major point from the analysis is that in a grazing system the greatest differences between large and small mature size beasts occur at intermediate carcass weights of around 250 kg. This is because this carcass weight can be achieved in 1 year of finishing by "900 kg" beasts but requires 2 years for "750 kg" beasts.

TABLE 4 Carcass gain (kg/ha) for the most efficient production system to produce each specified carcass weight.

	Beast mature weight		
Carcass weight (kg)	900 kg	750 kg	Difference
200	603	541	62
220	640	492	148
250	587	380*	207
270	478	369*	109
300	429*	324*	105
320	417*	274*	143

* 2 year finishing

DISCUSSION

A notable feature of the results is the consistent advantage in feed conversion efficiency to the largest mature size cattle. This occurred across a range of pasture utilisation rates and so was translated directly into greater carcass gain per ha. The mechanism used in the model to describe differences in potential intake, maintenance and growth relied on the mature weight scaling rules of Taylor (1980). The effect of these assumptions is that at a common level of maturity, cattle of different mature sizes have the same level of feed conversion efficiency when fed at the same fraction of potential intake.

Alternatively, at any given liveweight, cattle of greatest mature size have the greatest food conversion efficiency because they are least mature.

The reason for differences in average feed conversion efficiency between cattle types was that smaller mature sized cattle matured more quickly than large. They were also more mature as calves on 1 April.

Length of the finishing system has the greatest effect on animal conversion efficiency of any of the variables studied. Lower average conversion efficiencies in 2 year than 1 year finishing is the result of high overhead costs of maintenance feeding 2 year old cattle for the relatively small return in additional liveweight gain in the second year (average 55% of year 1).

Where 2 year finishing does become more biologically efficient than 1 year is when a constraint is imposed to produce high carcass weights which can only be achieved by very low levels of pasture utilisation in a 1 year system. This may not be as critical in integrated beef finishing systems where surplus feed can be used by other stock classes.

The advantage to animal conversion and biological efficiency of a 20% decrease in maintenance requirements was lower than could be achieved by increasing mature size by 20%. This suggests that in beef finishing, maintenance requirements are not as important an issue in determining carcass gain per ha as the mature size of the beast to be finished.

The results in this study apply to the situation where seasonal feed allocation is optimised with respect to final carcass weight. The model achieved maximum carcass weights by manipulating the cattle growth to ensure potential net pasture production was achieved over the farm in the deficit periods of winter and early spring. This meant maintaining average pasture mass on the farm above about 1350 kg DM/ha (see Fig. 1a) particularly at high stocking rates. The degree of autumn and winter restriction required on cattle growth therefore increased as stocking rate increased. This is shown in Figure 2 where optimal growth paths of 900 kg mature weight cattle are graphed for a high and low stocking rate. The sensitivity of pasture utilisation, animal conversion and carcass gain per ha to minimum pasture mass in early spring increased as stocking rate increased. This was because at low stocking rates optimal pasture masses were soon regained in early spring even if mass dropped as low as 1150 kg DM/ha.

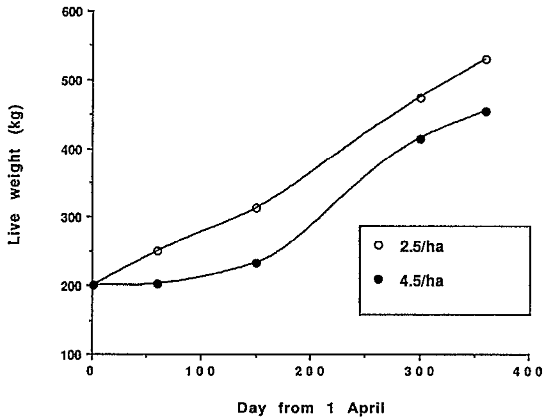

FIG 2 Growth paths which maximise carcass weight at 2 stocking rates for 900 kg mature weight beast.

The reason that average animal conversion efficiency was relativley constant across stocking rates under optimal management was because the high levels of conversion efficiency achieved during compensatory growth of high stocked cattle in spring, balanced the effects of low conversion efficiency in winter when they achieved very low growth rates.

The cost of allowing average farm pasture mass to decline below levels required for potential pasture production in early spring is a reduction in both annual pasture utilisation rate and animal feed conversion efficiency. The latter occurs because the depression in early spring pasture growth reduces compensatory growth opportunities by depressing animal intake for a longer time into spring.

CONCLUSIONS

The results of this study show that, within the bounds of optimal management, maximum BE with any cattle type will be achieved where around 95% of potential net pasture production can be consumed with a one year finishing system. This is most unlikely to be the economic optimum. The economic optimum pasture utilisation rate will depend on price differentials for differing size carcasses and the per head costs of purchasing and farming the cattle.

Irrespective of pasture utilisation rate the amount of feed required per kilogram carcass gain was always least in the highest mature size cattle. An additional advantage to high mature weight cattle is that they achieve greater carcasss weights in one year of finishing than low mature weight cattle.

Where desired carcass weights are in the range capable of being achieved in 1 year of finishing by high mature sized cattle but requires 2 years in lesser mature sized cattle, the difference in efficiency becomes even greater in favour of large mature sized cattle.

The results suggest that breeding cattle for high growth rates (mature size) appears to be the cheapest means of improving the cattle available for beef finishing, rather than being concerned with maintenance requirement as suggested by some breeders.

Contrary to the common practise of trying to achieve high cattle liveweight gains in winter to maximise carcass weights, the results suggest management strategies should aim to restrict winter liveweight gain as necessary to allow potential pasture production to be achieved through early spring.

This model analysis had identified strategies to optimise beef finishing on pasture, which will require field validation.

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