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Biological efficiency: How relevant is this concept to beef cows in a mixed livestock, seasonal pasture supply context?

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ABSTRACT

Efficiency, defined as the ratio of output to input, can be calculated for any product, and for any of the resources employed to generate that particular product. "Weight of calf weaned per unit cow liveweight" is commonly used to measure biological efficiency in the beef cow herd, based partly on the assumption that feed intakes and hence costs are related to liveweight. A more direct measure, and the one used here, is "weight of carcass produced per unit of feed intake". The biological efficiency of the traditional beef breeding cow, determined in this manner, is low compared to that of other beef cow systems (e.g. twinning cows, once-bred heifers). This is primarily because of the relatively low reproductive rate in traditional cow herds and the high proportion of annual feed consumption used to maintain the breeding female and her replacements.

A simple output/input ratio may not, however, be appropriate for the mixed sheep and cattle systems which are widely used in New Zealand. For these systems, where a competitive or complementary relationship may exist between enterprises, a more complex efficiency ratio that contains elements of the whole farm system is likely to be more appropriate. Furthermore, in a seasonal pasture production system, where the supply of feed is likely to limit production at certain times of the year, feed does not have a fixed value. Feed costs therefore become an important component of the efficiency equation. Utilisation by other livestock of a scarce resource (e.g. winter feed) is also likely to have an influence on the economic efficiency of the system. For example, if biological efficiency is ignored then output (weight of calf weaned) may be increased simply by increasing cow size but with no consideration of the extra feed inputs necessary to maintain larger cows, or the pressure that additional feed requirements may place on other components of the system at particular times of the year.

In this paper, the relevance of biological efficiency is explored by comparing both biological and economic efficiencies of four cattle systems - traditional beef cows, beef x dairy cows (with and without twinning) and once-bred heifers - alone and in mixed sheep and cattle policies. We conclude that biological efficiency is a relevant concept, primarily because its components (carcass weight and feed consumed) are also important determinants of economic efficiency. However marked differences between systems in the value of the carcass produced and/or feed consumed can lead to a poor correlation between the efficiency ranking of systems by biological and economic criteria.

Keywords: beef breeding cows; biological efficiency; once-bred heifers; twinning; beef x dairy cross cows.

INTRODUCTION

Efficiency is generally measured as the ratio of output(s) to input(s). The choice of ratio has to be related to the purpose for which efficiency is being measured and it is rare for any one measure of efficiency to be adequate for all purposes. For New Zealand pastoral systems of farming, biological efficiency could be described as the goodness of fit of animal feed demand and herbage supply subject to the constraints of minimum herbage wastage and maximum saleable animal product.

The weight of calf weaned per cow joined divided by average cow liveweight is a commonly used measure of biological efficiency in the beef breeding cow herd (e.g. Morris *et al.*, 1993). Measured in this way, the biological efficiency of the beef breeding cow is low compared with that of other domestic livestock (Coop, 1967; Spedding, 1975). This reflects the (compounded) result of a relatively low reproductive rate and the conversion of grass to milk and then to (calf) meat with loss of energy at each stage of the process. Thus the beef cow is capable of generating only about 0.7 of

her body weight in progeny marketed each year, compared to the sow which produces 8 times her body weight per year and the meat-type hen which produces 70 times her body weight per year in progeny market weight (Spedding, 1979).

Measures of biological efficiency which relate meat production to dam liveweight assume a constant relationship between dam liveweight and input costs, of which the most important are commonly feed costs. Such an assumption is clearly not valid when comparisons are made across species, and may also be questionable when comparisons are made between systems within a species. Thus a better measure of biological efficiency, and the one used here, is "weight of carcass produced per unit of feed intake". Even this definition may be questioned since, in grazing systems (in contrast to monogastric animal systems), feed intake may be controlled for purposes other than to influence the production of the animal at that time - for example, to control feed supply and quality, or to store feed energy in body reserves in preparation for times of the year when feed supply is insufficient to maintain production (Pleasants and Barton, 1994).

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Taylor *et al.* (1985), using an empirically based model, and Herd *et al.* (1993), using a linear program model, examined the overall efficiency of conversion of feed energy to lean meat in traditional, twinning and sex-controlled beef production systems. Two of the more efficient systems of beef production identified by these authors used twinning to produce more calves and a single sex, once-bred heifer (OBH) system. Twin-suckling of beef cows using foster calves has been a successful method of obtaining twins under New Zealand research conditions (Everitt and Phillips, 1971; McMillan *et al.*, 1993). Once-bred heifer beef production has also been successfully developed for New Zealand conditions and is a profitable alternative for New Zealand beef cattle farmers (Keeling *et al.*, 1991; Morris *et al.*, 1992; Khadem *et al.*, 1993). These systems therefore provide a useful basis for evaluating the relevance of biological efficiency since they differ widely in reproductive rate, amount and value of meat produced, and patterns and quantity of feed consumed, when compared with traditional beef breeding cow systems.

THE SYSTEMS AND MODELS

Four different systems of beef production were considered as a basis for evaluating the relevance of biological efficiency. They were:

1. *Traditional*: a 450 kg straightbred beef cow of British breed type (e.g. Angus) with a 90% weaning rate and an average calf weaning age of 200 days and weight of 220 kg. All calves from this system are sold at weaning, heifers are mated at 15 months of age and there is a herd replacement rate of 25%.
2. *Beef x dairy*: crossbred cows mated to a terminal sire - e.g. a 400 kg Angus x Jersey cow with a 90% weaning rate and an average calf weaning age of 200 days and weight of 250 kg (Baker *et al.*, 1990). Replacement rate is as for (1) above.
3. *Beef x dairy (twin)*: the same cow as in (2) but with a second (Friesian bull) calf fostered on at birth. A 90% weaning rate and 80% success rate at fostering give a weaning rate of 162%. All calves are weaned and sold at 150 kg at 140 days of age.
4. *Once-bred heifer (OBH)*: a Hereford x Friesian heifer mated to an Angus bull, with an 80% weaning rate, calves weighing 200 kg at weaning (200 days of age), the OBH being slaughtered at 235 kg carcass weight and the dry heifers (those which failed to conceive or which lost their calves) slaughtered at 240 kg carcass weight.

A series of spreadsheets were constructed to estimate the daily dry matter (DM) requirements for the various livestock classes in each beef system (Brookes *et al.*, 1993). These models are based on published equations for energy requirements (A.R.C., 1980), and require that feed quality be expressed as metabolisable energy concentration. Output is expressed as daily dry matter requirements for half-monthly periods throughout the year, as well as annual totals. These were then used as sub-routines to provide inputs to a feed budget model (Brookes *et al.*, 1992). Inputs to the feed budget

included: period of the year over which the budget operates; initial pasture cover and target cover at the end of the period; effective grazing area; net pasture accumulation rates; the number of animals in each class; and their daily DM intake at half-monthly intervals. Calculated outputs included total accumulated pasture growth and DM intake for each live-stock class during the budget period, and the difference between final and target pasture covers. The economic efficiency index was derived from the gross margin (defined as revenue from livestock less direct production costs, including the opportunity cost of capital invested in livestock wintered) divided by the annual feed consumption of the respective livestock policies considered. Carcass weight produced for each system assumed a dressing out percentage of 50% for weaner calves (Hiner and Bond, 1971) and 49% for once-bred heifers and 51% for the dry heifers. (Khadem 1994).

RESULTS AND DISCUSSION

Initially the different systems of beef production were compared as all-beef systems on a 50 ha Manawatu hill country farm. Each policy was assumed to consume 7200 kg DM/ha/yr and, within each policy, the numbers of animals in the different stock classes were varied to meet this constraint. Table 1 gives the biological efficiency (g carcass produced/kg DM eaten) and economic efficiency (\$ Gross Margin return/tonne of DM consumed) for each system.

TABLE 1: Comparison of biological and economic efficiency of different breeding cow policies under a cattle - only scenario

Policy	Biological Efficiency (g carcass/kg feed consumed)	Economic Efficiency (\$ GM ¹ /tonne DM consumed)
Traditional	34 (100) ²	88 (100) ²
Beef x dairy	44 (129)	115 (131)
Beef x dairy (twin)	46 (135)	136 (154)
Once - bred heifer	49 (144)	100 (114)

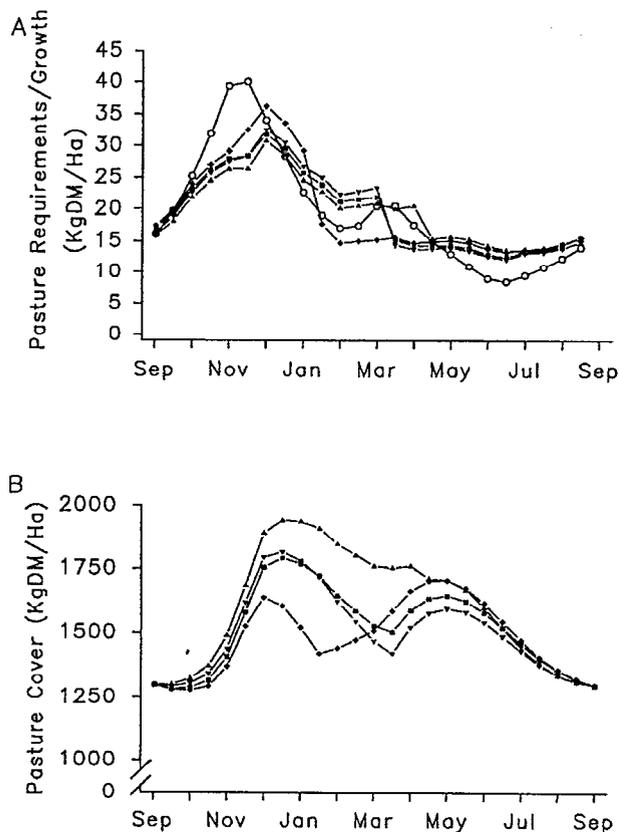
¹GM = Gross Margin

²Relative to traditional system (=100)

The OBH system ranked first for biological efficiency but, for economic efficiency, ranked third behind the beef x dairy (twin) and the beef x dairy cow mated to a terminal sire. This reflected the high value of product (value per kg of calves sold) from the latter two systems which primarily produce calves for sale at weaning. The OBH system, however, generated a larger proportion of its revenue from heifer beef sales which return a lower price per kg than live weaner calf sales. This highlights the point that biological efficiency and economic efficiency will be poorly correlated when the values of output (in this case meat) vary between the systems being compared.

The next step was to compare the various beef cattle production systems in a mixed "beef cattle plus sheep" system. This involved fitting the different beef cattle systems into the 341 ha Massey University Tuapaka hill country farm, for which sheep numbers were assumed to be fixed at 1600 breeding ewes plus replacements. Cattle numbers were varied between policies to utilise the excess feed not consumed by sheep (total consumption for sheep plus cattle was again

FIGURE 1: Pasture growth (o) and feed requirements for traditional (■), beef x dairy (▼), beef x dairy (twin) (◆) and OBH (▲) beef production systems (Panel A) together with pasture cover (kg DM/ha) (Panel B) on a sheep and cattle farm with an annual consumption of 7200 kg DM/ha/yr.



7200 kg DM/ha/year). A further constraint, to ensure a sustainable livestock production system, was that average pasture cover should not fall below 1000 kg DM/ha or rise above 2500 kg DM/ha at any stage of the year (Gray, 1987).

The feed intake patterns for the various beef production systems, in which each system consumed 7200 kg DM/ha/yr, together with the typical pasture growth pattern for Tuapaka, are shown in Figure 1. High feed requirements for the beef x dairy (twin) cows in spring reflect the higher feed intake of the double-suckled cows and their calves over this period compared with the other beef cow policies studied. After weaning and sale of calves at 140 days this system generated lower monthly feed requirements than the other systems. The OBH system had the lowest feed intake throughout the spring period, primarily because a large proportion of the cattle are replacement non-pregnant/lactating heifers. Because of the need to feed the weaned dams in the OBH system to target slaughter weights, there is a higher autumn feed demand in this system than for the other policies in which replacements represent a lower proportion of the cattle stock units wintered. The feed intake patterns for the "traditional" and the "beef x dairy cow mated to a terminal sire" cattle systems had much less variation in feed demand than either the beef x dairy (twin) or the OBH system.

Results for the "sheep plus cattle" scenario are presented in Table 2. The biological efficiency for the mixed system was measured in grams of "sheep plus cattle" carcass weight produced per kg DM consumed. The rankings of each

TABLE 2: Comparison of biological and economic efficiency of different breeding cow policies under a cattle plus sheep scenario.

Policy	Biological Efficiency (g sheep + cattle carcass/kg feed consumed)	Economic Efficiency (\$ GM ¹ /tonne DM consumed)
Traditional	26 (100) ²	70 (100) ²
Beef x dairy	31 (120)	80 (113)
Beef x dairy (twin)	32 (125)	93 (132)
Once-bred heifer	34 (133)	79 (111)
Once-bred "cow" ³	34 (133)	68 (97)

¹GM = Gross Margin

²Relative to traditional system (=100)

³Heifer carcass valued as cow meat

policy remained the same as for the cattle - only situation, but the absolute values were reduced because of the lower carcass output per kg DM consumed from the sheep. When economic efficiency is considered, the rankings were similar to those of the "cattle - only" scenario, again reflecting the lower value per kg of carcass from the OBH system compared with the value when selling live calves at weaning in the beef x dairy systems.

The impact of product value on measures of efficiency is further illustrated in Table 2 by the "once-bred cow" system. This assumes that the once-bred animal is graded as cow beef. This situation existed prior to the redefinition of the "heifer grade" (as an animal with no more than 6 permanent incisor teeth erupted) in 1988. The OBH and cow have the same biological efficiency (carcass weight produced/feed consumed) but very different economic efficiencies because of the different values assigned to each unit of carcass produced.

Finally, it is important to note that, just as changes in the dollar value of output (e.g. meat) alter the relationship between biological and economic efficiency, so too do changes in the dollar cost of inputs (e.g. feed). However, whereas differences in meat value can be defined for different systems with relative ease, defining the overall feed cost for a particular system is difficult. Biologically, the dollar value of each kg of DM is determined by the time of year in which it is grown, its contribution to filling deficits or creating surpluses (relative to feed requirements of the system) and the extent to which it maintains its nutritive value if harvested or otherwise conserved and subsequently fed to an animal. Economically the dollar value of DM can be determined by either its opportunity cost or its marginal value product. The opportunity cost provides a measure of how much profit is forgone by adopting the current livestock policy relative to the most profitable option available to the farmer (i.e. if the most profitable policy is already in place there will be no opportunity cost on the feed utilised by that policy). The marginal value product, on the other hand, provides an estimate of the value of one extra unit of feed in the month concerned for the current livestock policy. Such values can be derived from the shadow prices generated by a linear programming model with monthly time steps (see Gray *et al.*, 1994 for an example). Clearly, an extra unit of feed on hill country farms in months of surplus growth will have no immediate value (although it may have a carry over value in subsequent

months if feed is in short supply at these times). In some situations it may, however, be more appropriate to express the efficiency of livestock policies relative to an investment criterion (e.g. rate of return on livestock capital), or a limiting resource such as labour, rather than feed utilisation.

CONCLUSION

Biological efficiency, as defined in this paper, is relevant to different beef cattle breeding cow systems primarily because its components (carcass weight produced and feed consumed) are also important determinants of economic efficiency. However, it was assumed in the examples examined here that feed has a constant value throughout the year, which is rarely true. More sophisticated models are required which differentially value feed throughout the year. The relevance of biological efficiency can also be altered by changes in product value, and such changes need to be taken into account when assessing the economic efficiency of different systems.

REFERENCES

- ARC 1980. The nutrient requirements of ruminant livestock. Commonwealth Agricultural Bureaux, Farnham Royal, UK.
- Baker, R.L.; Carter, A.H.; Morris, C.A.; Johnson, D.L. 1990. Evaluation of eleven cattle breeds for crossbred beef production: Performance of progeny up to 13 months of age. *Proceedings of the New Zealand Society of Animal Production* 50: 63-77.
- Brookes, I.M.; Parker, W.J.; Gray, D.I. 1992. The role of computer software in the feeding of farm livestock. *Proceedings of the New Zealand Society of Animal Production* 52: 111-114.
- Brookes, I.M.; Morris, S.T.; Parker, W.J. 1993. Computer spreadsheets for predicting feed requirements and feed budgeting. *Proceedings of the New Zealand Grassland Association* 55:(in press)
- Coop, I.E. 1967. The efficiency of food utilisation. *Proceedings of the New Zealand Society of Animal Production* 27: 154-165.
- Everitt, G.R.; Phillips, D.S.M. 1971. Calf rearing by multiple suckling and the effects on lactation performance of the cow. *Proceedings of the New Zealand Society of Animal Production* 31: 22-40.
- Gray, D.I. 1987. A case farm study of high and low sheep performance on southern North Island hill country. *MAgrSc Thesis*, Massey University, Palmerston North.
- Gray, D.I.; Yuretich, P.A.; Lynch, G.L. 1994. Farm management implications of a seasonal price differential for factory supply milk production. *Proceedings of the New Zealand Society of Animal Production* 54: 383-388.
- Ferrell, C.L.; Jenkins, T.G. 1984. Energy utilisation by mature, non pregnant, non lactating cows of different types. *Journal of Animal Science* 58: 234-243.
- Herd, R.M.; Bootle, B.W.; Parfett, D.C. 1993. An economic evaluation of traditional, twinning and sex-controlled systems of beef production in Southern Australia. *Australian Journal of Agricultural Research* 44: 1541-1546.
- Hiner, R.L.; Bond, J. 1971. Growth of muscle and fat in beef steers from 6 to 36 months of age. *Journal of Animal Science* 32: 225-232.
- Keeling, P.C.B.; Morris, S.T.; Gray, D.I.; Parker, W.J. 1991. A modelling study of once-bred heifer beef production. *Proceedings of the New Zealand Society of Animal Production* 51: 389-393.
- Khadem, A.A.; Morris, S.T.; Parker, W.J.; Purchas, R.W.; McCutcheon, S.N. 1993. Herbage intake, ingestive behaviour, and growth performance in unbred and once-bred Hereford x Friesian heifers. *New Zealand Journal of Agricultural Research* 36: 435-444.
- Khadem, A.A. 1994. Nutritional, genetic and meat quality aspects of once-bred heifer beef production systems in New Zealand. PhD thesis, Massey University, Palmerston North.
- McMillan, W.H.; Evans, P.H.; Hall, D.R.H.; McLean, M. 1993. Twin-suckling beef cows using foster calves: effects on calf and cow performance. *Proceedings of the New Zealand Society of Animal Production* 53: 203-205.
- Morris, C.A.; Baker, R.L.; Hickey, S.M.; Johnson, D.L.; Cullen, N.G.; Wilson, J.A. 1993. Evidence of genotype by environment interaction for reproductive and maternal traits in beef cattle. *Animal Production* 56: 69-83.
- Morris, S.T.; Parker, W.J.; Purchas, R.W.; McCutcheon, S.N. 1992. Dairy crossbreeding alternatives to improve New Zealand beef production. *Proceedings of the New Zealand Grassland Association* 54: 19-22.
- Pleasant, A.B.; Barton, R.A.; McCall D.G. 1994. Nutritional buffering. Do we make best use of this phenomenon in the breeding cow. *Proceedings of the New Zealand Society Animal Production* 54: 329-332.
- Spedding, C.R.W. 1975. *The Biology of Agricultural Systems*. Academic Press, London.
- Spedding, C.R.W. 1979. *An Introduction to Agricultural Systems*. Applied Science Publishers Ltd, London.
- Taylor, St. C.S.; Moore, A.J.; Thiessen, R.B.; Bailey, C.M. 1985. Efficiency of food utilization in traditional and sex-controlled systems of beef production. *Animal Production* 40: 401-440.