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The complementary contribution of the beef cow to other livestock enterprises

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ABSTRACT

This paper reviews potential benefits of beef cows to other livestock enterprises on a sheep and beef farm. These benefits may include general benefits of cattle such as improved sheep performance via improved pasture quality. They may also include benefits specific to cows such as the efficient use of low quality feed and feed demand patterns which match pasture production. A linear programming model is used to quantify complementary benefits of breeding cows to the total farm economy. This is done by comparing the profit from finishing only policies with those that include breeding cow and finishing cattle policies. When the marginal benefit in farm profit is all attributed to the breeding cows their worth is between 5 and 26% greater than estimated by an enterprise analysis which does not account for complementarity. However, complementary benefits cease when returns from finishing reach $16/su greater than cows. Field system trials are required to validate these conclusions.

Keywords: model; optimum; profit; mixed grazing; sheep/cattle ratio.

INTRODUCTION

My brief was to discuss the complementarity of beef cows with other enterprises on a pastoral farm and to suggest methods of quantifying benefits. The approach I have taken is to first review aspects of complementarity between beef cows and other stock classes. Next, I present the results of a simple modelling analysis which sought to quantify benefits from complementarity. The paper is concluded with a discussion which highlights differences between the analyses and perceived benefits reasoned from first principals; and the difficulties in quantifying all benefits in a model.

Complementarity between stock classes - potential benefits

From a farmer's perspective there are a number of aspects to complementarity between stock classes. At the biological level there may be benefits from improved weed control and improved utilisation rates of pasture through complementary feed preferences. These in turn may have a positive carryover effect on the future quality and quantity of pasture. Complementarity between stock classes in the pattern of feed requirements may also improve pasture utilisation rates by allowing a higher stocking. Further benefits may occur in situations of unexpected feed surpluses or deficits where feed can be preferentially directed to the stock class giving the greatest potential production response to available feed. Finally, benefits from interspecies complementarity may accrue through improved animal health due to reduced gastro-intestinal worm burdens.

At an economic level the combination of cattle and sheep provides a portfolio of products (lamb, beef and wool) to buffer income against price fluctuations in any one product. The correlations between sheep meat, beef and wool prices are such that seldom are all three severely depressed at one time. Linked to economics is the issue of complementarity of enterprise labour demands on a farm. For example, a portion of cattle stock units reduces peak work loads at shearing and docking compared to an all sheep policy.

The above discussion serves to highlight that at the farm business level, complementarity between stock classes takes on wider significance than when viewed at a biological level. Having recognised this, the remainder of the paper is devoted to the feed supply aspects of complementarity between beef cows and other stock classes.

Complementarity between cattle and sheep grazing

One of the major areas of complementarity between cattle and sheep is that of pasture quality. Mixed grazing of beef cows with sheep has been a feature of New Zealand hill country farming for many years. Cattle have been used in pasture development and to control excess pasture and the associated regeneration of undesirable species (Suckling, 1975).

A major complementary benefit from cattle has come from improvement of pasture quality from late spring through to the autumn (Suckling, 1975). Experimental evidence suggests that sheep are the main benefactors with little or no effect on finishing cattle liveweight gains (Hamilton, 1976; Boswell and Cranshaw, 1978; McCall 1987). Hoggets grazing with cattle have grown up to 18 kg more than those grazing solely with other hoggets over the 9 months from spring to autumn (Boswell and Cranshaw, 1978). Ewes have grown an extra 3 kg liveweight and 0.2 kg wool over summer (McCall *et al.*, 1986). Furthermore, hoggets grazing behind cattle have achieved similar or better weight gains than those grazing alone (Boswell and Cranshaw, 1978). Around 40% of the feed demand in mixed species mobs needs to come from cattle to enable maximum benefit in sheep performance without detriment to cattle liveweight gain (McCall, 1987).

Cattle grazing behaviour assists clover by leaving stolons intact (Snell, 1935). Mixed sheep and cattle grazing also improves the sward structure for sheep. Sheep seldom penetrate into grazing horizons containing pseudostem (Barthram, 1980) and their preference for grazing pasture declines above 8-10 cm (D.A. Clark unpub). Benefits from the cattle include making available larger areas of feed in the preferred grazing horizon for sheep (Suckling 1975). Benefits due to sheep are undoubtedly in developing more densely tillered swards (Monteath *et al.*, 1977, Hodgson *et al.* 1987) which promote greater annual levels of pasture production than under solely cattle grazing (Boswell, 1976, Monteath *et al.*, 1977).

A second area of complementarity may exist during winter on hill country farms due to complementarity of the diet, thus allowing greater feed utilisation. Complementarity between the diets of sheep and beef cows has been claimed for some time (Snell, 1935). Under conditions of interspecies competition for feed, cows will eat more dead grasses and non-herbaceous weeds such as ferns which are not prefered by sheep. Sheep on the other hand will eat herbaceous weeds ignored by cattle. On intensively managed pastures there is little potential for benefits from mixed grazing during winter because of the lack of variability in pasture composition. Instead there is a high level of competition for all available pasture.

Finally, beef cows have a role in removing surplus, low quality summer pasture not readily eaten by sheep. This pasture removal promotes greater autumn and winter pasture growth (Sheath and Boom, 1985). Beef cows are the most efficient stock class at consuming this pasture as they continue to support acceptable calf growth rates (McCall *et al.*, 1988).

The precise mechanism by which mixed grazing advantages sheep, particularly during spring and summer, is unclear. As mentioned, less area of the pasture evolving into tall unacceptable sites for sheep grazing and enhanced levels of clover have been credited (eg McCall *et al.*, 1986). Less rejection of pasture around cattle dung areas has also been credited for greater overall pasture utilisation and quality thus allowing cattle performance to be maintained in the presence of sheep (Nolan and Connolly, 1977). The debate relates to whether or not true complementarity exists or whether many mixed grazing experimental results are artifacts of confounding with grazing pressure (Nolan and Connelly, 1977; Arosteguy, 1982). Both Reynolds *et al.* (1971) and Hodgson *et al.* (1987) have claimed little or no total animal production benefits from mixed grazing where pasture levels are maintained constant between treatments using additional stock under 'put and take' procedures.

Not withstanding the latter results it seems that mixed sheep-cattle grazing can be used to practical advantage from late spring to autumn in most farming situations. At this time a surplus rather than a shortage of pasture is a problem and any grazing strategy which improves pasture intake by improving the clover content, reducing selectivity or increasing grazing pressure is preferred. Farmers have widely recognised the benefits of using beef cows to prepare quality feed for lamb growth (Parminter *et al.*, 1993). While finishing cattle can control pasture quality for lambs and still maintain acceptable growth rates (Sheath *et al.*, 1990), farmers favour the use of breeding cows (Parminter *et al.*, 1993).

Complementarity of cow feed requirements

Two further areas often claimed as important complementary features of beef cows are their feed demand pattern and their ability to buffer feed restrictions (eg Pleasants *et al.*, 1991). The underlying pattern of feed requirements of beef cows can match the pattern of feed supply better than other cattle stock classes (Sheath *et al.*, 1988). Flexibility occurs because cow body weight reserves can be used to buffer calf growth against seasonal variability in quantity and quality of pasture. Smeaton *et al.* (1983) showed severe restrictions in cow intake in early spring have little effect on calf weaning weight although severe feed restriction over the two months post calving can lower reproductive performance. Later calving beef cows appear to be extremely resilient to prolonged feed restriction over winter (Pleasants *et al.*, 1991). This provides additional flexibility to buffer variability in autumn and winter feed supply, Finally, cows in fat condition in mid summer use body reserves to maintain calf growth when grazing low quality pastures. Unweaned 5 to 7 month old calves grazing low quality pasture grow faster than calves weaned at 5 months of age onto hay aftermath (McCall *et al.*, 1988).

QUANTIFYING BENEFITS OF COMPLEMENTARITY

Method and assumptions

A simple Linear Programming (optimising) model (LP) was constructed in an attempt to quantify the benefits of using cows on the total farm economy. An LP approach has been used by others (eg Connolly, 1974) to address the related problem of the optimum carrying capacity of rangeland.

The aim of the present analysis was to quantify specific advantages of using beef cows on a sheep and beef farm, rather than to quantify benefits of cattle, *per se*. Hence, sheep performance levels assumed in the model were those achievable under mixed sheep-cattle grazing (eg McCall *et al.*, 1986; McCall, 1987; Sheath *et al.*, 1990). Financial benefits from using beef cows were calculated relative to returns from using solely finishing cattle in the system.

A number of other assumptions were made in order to construct the LP model. The model was developed for a hill country property with no pasture conservation. Assumed pasture growth rates are given in Appendix 1. A pasture surplus control strategy of retiring pasture from grazing was assumed. The decision rule was to retire an area of the farm on 1 November such that pasture cover on the remaining grazed area never exceeded 2200 kgDM/ha. This has been determined as a critical level for maintaining pasture quality and control (G.W. Sheath, pers comm). Pasture retired at this time grows to a ceiling yield of about 5 t DM/ha and may be about 50 % dead matter. This ceiling yield was assumed in the model. It was assumed that only cattle could consume retired pasture in late summer (1 February to 30 April). Sheep appear less successful at consuming this rank pasture. Finally, no supplementary feeding was undertaken.

Two sheep and five cattle policies were explored from which the optimal policies based on total farm gross margin were selected. Pasture production was capable of supporting about 15 su/ha. The model was constrained to a minimum of 7 sheep su/ha. This minimum was deemed necessary to sustain productive pasture on hill country. A maximum of 9 sheep su/ha was specified to ensure the model maintained an acceptable ratio of cattle for spring - summer grazing. A stock unit was defined as the annual dry matter requirement of one ewe plus her replacement hogget (ie 560 kg DM). The two sheep options were a store lamb policy with all surplus lambs sold in December and a finishing policy where the top 75% of ram lambs were retained and finished at 15 kg carcass weight.

Three finishing cattle options were examined. The first 2 assumed that finishing cattle were priority stock and were not used to consume late summer surpluses. These were a one- and two-year bull beef finishing policy achieving 228 kg and 300 kg average carcass weight, respectively. Replacements were purchased on on 1 April. The third policy, a two-year policy, allowed finishing cattle to eat surplus pasture. Bull growth rates while grazing surplus pasture were assumed to be -0.1 and 0 kg/day for the one- and two-year old cattle, respectively (Sheath *et al.*, 1984). The affect of cleaning up surplus pasture resulted in an average carcass weight of 273 kg for this two-year policy, or a cost of 27 kg carcass weight.

Self-replacing breeding cow policies investigated were early weaned cows (31 January) or early weaned first calver's and late weaned (1 April) cows. All cows and first calver's were used to graze surplus pasture. Both breeding cow options were designed to achieve a minimum liveweight of 380 kg post calving (Smeaton *et al.*, 1979). Performance details of cows and calves in late summer were taken from McCall *et al.*, (1988). Early weaned calves were assumed to be 12 kg lighter on 1 April (McCall *et al.*, 1988) when all but replacement heifers (30%) were sold. Replacement heifers were mated at 14 months. Their requirements were included as part of cow requirements and it was assumed that 20-month old heifers could be used to graze surplus pasture. A 20% cow replacement was assumed with the remaining (non-pregnant) heifers sold in late March. Early weaned calves were assumed to be fed on controlled pasture in late summer along with sheep and the priority finishing cattle. Feed requirements for each policy were derived using Stockpol (Marshall *et al.*, 1991). A table of these, and annual stock unit conversions used, is given in Appendix 1.

Experimental approach

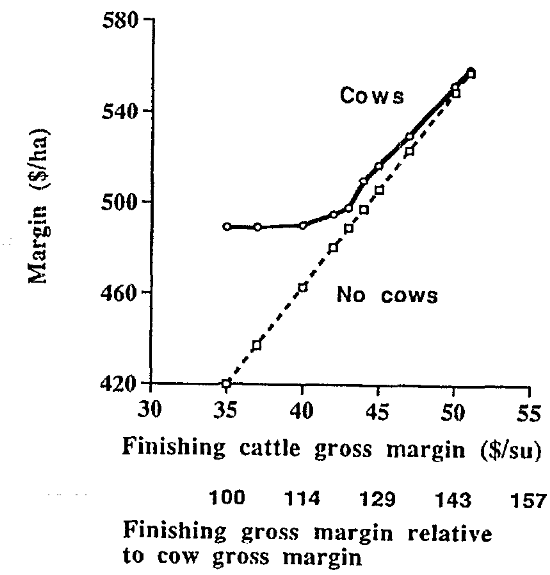
To test the complementary benefits of beef cows the LP model was solved to give optimal policies either with or without the option of cows. Financial benefits from using cows were first viewed by comparing returns between the 'cow' and 'no cow' options given equal profitability (gross margin/su) across all stock classes. This reflected benefits from efficiency of feed use and did not confound feed use efficiency benefits with market advantages of one stock class over another. Next, the importance of complementary benefits from 'cow' policies were tested as the profitability of finishing cattle was increased.

Gross margin per stock unit from the finishing sheep policy, the two priority cattle finishing policies and the late weaning cow policy were all set to $35 based on the stock units shown in Appendix 1. The gross margin of the store sheep policy was calculated to be $4.30 less than a lamb finishing policy (ie $31.70/su) and the early weaning cow policy $15 less per cow wintered than late weaning (ie $32.60/su). Depending on schedule price assumptions the cost of the reduced carcass weight from grazing surplus pasture using finishing cattle is between $60 and $100 per head. A figure of $100 was used to accentuate the effect, giving a return of $22.50/su for this policy.

RESULTS

Figure 1 presents gross margins per hectare for optimal sheep / cattle policies for both 'cow' and 'no cow' options as returns from finishing cattle increase relative to other policies.

FIGURE 1: Gross margin ($/ha) advantage of cow compared to no cow policies over a range of finishing cattle gross margins ($/su). Cow gross margin constant ($35/su).



The advantage of the stock policies with cows present is an indication of the complementary benefits of cows to total farm profit at any finishing cattle gross margin. The comparison between 'cow' and 'no cow' policies *at the same return per stock unit* is shown by the first pair of points on the graph. The $69/ha advantage (ie 489 - 420) from incorporating beef cow policies was mainly due to no penalty to cow returns from grazing low quality pasture in the autumn.

The optimal solution with cows included 51% of total stock units as cows compared to 49% of stock units as low priority finishing cattle in the 'no cow' system (Table 2). Total stock units were 14.7 and 15.2 su/ha for 'cow' and 'no cow' policies, respectively. The lower total stocking rate in the cow option was because of a slightly lower pasture utilisation rate due to more pasture being retired in spring. Sheep options favoured store sheep where no cows were present. The late weaning cow policy was always optimal. Optimal solutions for priority finishing cattle generally favoured two-year finishing.

As the finishing cattle gross margin increased (Fig. 1), the increased returns compensated for the production penalty due to grazing low quality pasture. Most of the complementary benefit disappeared at a finishing gross margin of $43/su, 23 % (or $7/su), greater than cows. However, there was still

TABLE 1: Benefits of cows ($35/su) to total farm gross margin ($/ha) at varying gross margins for finishing cattle ($/su).

Variable	Finishing Gross Margin ($/su) 35	43	50
Gross margin with cow policy ($/ha)	489	498	552
Gross margin with no cow policy ($/ha)	420	489	549
Difference in gross margin ($/ha)	69	9	3
Cow numbers (su/ha)	7.5	4.9	1.3
Effective increase in cow gross margin/su (%)	26	5.1	6.5

TABLE 2: Optimal policies.

Finishing Cattle GM ($/su)	35		50	
Policy	Cow	No Cow	Cow	No Cow
Total su/ha	14.7	15.6	15.4	15.6
% sheep su	48	45	45	45
% high priority finishing cattle su	1	6	14	6
% low priority finishing cattle su	-	49	32	49
% cow su	51	-	9	-

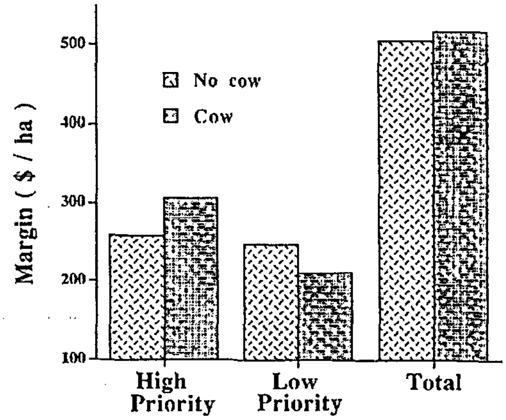
a small benefit from some cows in the policy until finishing gross margin reached $51/su, 46 % (or $16/su) greater than cows (Fig. 1). These benefits represent complementary benefits of cows through feed use efficiency, despite much lower product returns.

One method of viewing cow complementary benefits to the total farm economy is to credit all the financial advantage between the 'cow' and 'no cow' policies to the cows (Table 1). The first point to note is that the number of cow stock units drops as finishing gross margin increases. The second point is that the effective gross margin per stock unit of cows ranges between 5 and 26% above the gross margin per stock unit calculated from annual feed requirements. The reason for small complementary advantages from cows despite lower product value was because of greater returns from high priority stock (Fig. 2) due to a greater proportion of priority stock carried when cows were present (Table 2).

Implications of Results

The complementary benefits of beef cows to total farm profit were smaller than expected given previous component analyses (eg Sheath *et al.*, 1988). The major benefit occurred due to the lack of a penalty to cow profitability from grazing rank pasture. However, increased product values for finishing cattle eventually eliminated this benefit. Reasons for a smaller than anticipated benefit from cows may have been due in part to the decision to graze replacement heifers as part of the beef cow enterprise. These formed 19% of the total cow stock units. They are a high priority stock class during winter and their feed demand pattern may dampen benefits of the breeding cow enterprise in matching the feed supply pattern. Future policy analyses should check benefits from a non-self-replacing herd where heifers are purchased pre-heifer mating and all cows are mated to a terminal sire.

FIGURE 2: Breakdown of total gross margin ($/ha) between high and low priority stock classes for a cow gross margin of $35/su and a finishing gross margin of $50/su.



Limitations of the analysis.

No allowance was made for differing residual feed requirements between stock classes. Higher pasture residuals required by finishing cattle compared with cows may result in more pasture wastage. In addition, finishing cattle were assumed to be as effective as cows in grazing retired pasture. This may not be so, particularly when younger cattle are used for three months. Too, no allowance was made for cows eating weeds on hill country over winter. Finally, the analysis did not incorporate benefits of cows in buffering the performance of other stock from variable pasture growth.

SUMMARY AND CONCLUSION

The purpose of the analysis was not to be exhaustive but was rather to describe one methodology to quantify the benefits of complementarity. Regardless of the caveats, the analyses showed the need to evaluate the contribution of breeding cows in terms of whole farm profitability rather than by enterprise gross margin comparisons. There are clearly benefits of the cow due to complementary feed requirements with other stock classes. These may be worth up to 26% more than estimated by an enterprise analysis which does not account for complementarity. However, where the gross margin per stock unit from finishing exceeds that for cows by about 20 %, little complementary benefit remains.

Difficulties in incorporating all complementary mechanisms in a model suggests a need for a field trial to compare input/output relationships for breeding cow and 'no cow' systems on which to base future economic evaluations of complementary benefits.

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APPENDIX 1: Pasture growth and feed requirements (MJ ME/h/day) used in the model.

Month	Pasture Growth (kg DM/day)	Sheep Lamb Finish	Sheep Store	Cattle 1 year finishing	Cattle 2 year finishing (high priority)	Cattle 2 year finishing (low priority)	Cow Early wean	Cow Late wean	Weaned Calf
June	10	11	11	53	46	44	46	51	0
July	9	11.1	11.1	56	46	45	55	59	0
August	18	11.8	11.8	68	52	51	73	77	0
September	25	16.2	16.2	83	83	81	111	116	0
October	45	23.6	23.6	93	102	98	143	146	0
November	75	29.5	29.5	109	117	112	158	162	0
December	35	22.3	18.1	84	90	86	163	168	0
January	20	16.7	13.9	51	57	56	143	136	0
February	15	14.6	12.2	27	40	30	58	93	37
March	15	13.9	12.6	21	39	28	46	85	39
April	20	12.6	12.4	66	56	25	39	40	27
May	15	11.3	11.3	57	53	45	52	54	0
Annual	9 060	5 838	5 511	23 040	23 430	21 030	32 610	35 610	3 090
Stock units		1	1	4	4	4	6.2	6.2	-
Gross margin ($/SU)		35	30.7	35	35	22.5	32.6	35	-