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A program to assess the efficiencies of sheep-meat production systems: a teaching aid

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ABSTRACT

A computer program written in Visual Basic within a spreadsheet was developed to illustrate how the efficiency of a sheep-meat production system varies when changes are made in any or all of 32 variables. System performance is expressed in monetary terms as either the efficiency (E) in dollars returns per dollar cost (with a break-even value of 1) or as a profit. Costs and returns for ewes, rams and lambs are taken into account, and all are expressed on a per ewe per year basis. A single per kilogram price for mutton is used, but for lambs, the proportion falling into various classes at any carcass weight is calculated using a specified GR/carcass weight relationship in a separate simulation program. Relationships within the E-program are based on published data, such as those in lamb feed requirement tables. This program has proved useful as an aid to evaluating some repercussions of making various combinations of changes to sheep-meat production systems.

Keywords: lamb growth; spreadsheet model; meat production; system efficiency

INTRODUCTION

When comparing different systems of sheep-meat production, or assessing the effects of making changes to a particular system, there are many factors that should be taken into account because of interactions and interdependencies between parameters that determine overall system efficiency. This paper describes a simple model set up within a spreadsheet program (Microsoft Excel) that incorporates some of these interactions in order to facilitate the making of such comparisons. The model is based on that described for beef cattle by Dickerson (1970, 1985), in that returns associated with the system are expressed relative to the costs to give a measure of efficiency. It differs from that of Dickerson (1970) in that it is for a sheep-meat production system rather than for beef cattle and it takes into account the returns and costs associated with the breeding males as well as the breeding females and offspring. Dickerson expressed "efficiency" as costs per year relative to the economic value of product per year, which means that low values indicated an improved efficiency. In this paper, the efficiency equation is the reciprocal of that suggested by Dickerson so that higher values indicate an improved efficiency. Both input and output items are expressed in terms of dollars because this is the most satisfactory common unit for inputs and outputs measured in a range of units.

METHODS

The base sheep-meat production system considered was one in which all lambs are sold for meat production and replacement ewes, which are bought in as two-tooths (*c.* 17mo of age), are mated to a terminal sire. The efficiency equation to give E values in terms of dollars income per ewe per year, for each dollar of costs per ewe per year is as follows:

$$E = \frac{TotalIncome(\$)}{TotalCosts(\$)} = \frac{\begin{bmatrix} EweIncome \\ perYear(\$) \end{bmatrix} + 1/n \begin{bmatrix} RamIncome \\ perYear(\$) \end{bmatrix} + N \begin{bmatrix} LambIncome \\ perYear(\$) \end{bmatrix}}{\begin{bmatrix} EweCosts \\ perYear(\$) \end{bmatrix} + 1/n \begin{bmatrix} RamCosts \\ perYear(\$) \end{bmatrix} + N \begin{bmatrix} LambCosts \\ perYear(\$) \end{bmatrix}}$$

Where: n = number of ewes per ram, and
N = number of lambs marketed per ewe

The "*Income*" items on the right-hand side include returns from meat production as well as returns from wool production, with the former spread over the number of years the animals are kept in the system. "*Costs*" items include overheads per unit time, feed costs, and buying-in costs. Where appropriate, items are adjusted for a per-year mortality value with the simplifying assumption that animals die in the middle of the year. Levels of performance, such as lamb weaning weight, post-weaning growth rates, and lambing percent, are specified rather than being estimated from feed supplies or other determinants.

The nature of the 32 variables and their values used for the basic scenario used here are given in Table 1, and equations used to calculate derived values from these variables are outlined in Table 2. Pre-weaning growth rate is not specified as such, but is implied indirectly as a weaning weight. Thus, the default weaning weight of 25kg for a single lamb (Item 1 Table 1) corresponds to an 82-day old lamb with a birth weight of 4.5kg growing at 250gd^{-1}.

Average carcass price per kilogram for ewes and rams was set at a constant value regardless of carcass weight or class (Items 3 and 12, Table 1), but for lambs the returns per kilogram were determined in part by carcass weight, carcass fatness in terms of GR values, and the pattern of change in GR with increasing carcass weight. This was done by running the lamb-drafting model reported by Garrick *et al*. (1986) with mobs of 1000 lambs that were drafted at live weights of from 26kg to 58kg at 2kg intervals. Outputs for each live weight were average carcass weight and proportion of total weight in each export carcass class (NZMPB, 1992). With this information, and lamb carcass schedule values, an average per-kilogram price for any carcass weight can be calculated. These were entered in a Lookup table within Excel for carcass weights from 7 to 26 kg at 0.5kg intervals. Patterns of change in price were included for late-maturing lambs (GR=-8+0.9(Carcass weight)), early-maturing lambs (GR=-13+1.5(Carcass weight)), and medium-maturing lambs. Prices for medium-maturing lamb carcasses were mid-way between the early- and late-maturing groups. Based on prices at 1 November 1999(c kg^{-1}), the estimated average prices per kilogram showed an initial rise from 135c at 7kg (the schedule value for A class carcasses) to a maximum of 339c at 15kg and then a decline to 272c at 25kg as a greater proportion of carcasses fell into T and F classes.

Feed requirements for lambs up to weaning were included as part of the feed requirements for the ewe with the extra feed for raising a lamb or lambs to weaning being determined by the number of lambs raised and by weaning weight according to Equation 1 in Table 2. Thus, for a single lamb with a weaning weight of 25kg, the extra feed required was 1500 MJ ME, while for twins it is 2501 MJ ME.

Equation 2 (Table 2) indicates that the weaning weight differential between singles and twins will be 4kg. Lamb feed requirements for growth over and above maintenance given by Equation 3 (Table 2) closely match those in published feed-requirement tables (e.g., Geenty & Rattray, 1987).

Dressing-out percent values for lambs increase with increasing final live weight according to Equation 4 (Table 2). The post-weaning ADG of lambs was scaled by the mature weight of their parents according to Equation 5 (Table 2). The exponent of 0.73 is that suggested by Taylor (1985).

To run the program, values for the 32 variables were entered for up to 5 scenarios in the main data worksheet, and then efficiency and profit values could either be read off directly, or one of the 32 variables could be selected as an X variable. A graph was then produced showing efficiency or profit on the Y axis versus a range of the selected X variable that is built into the program (Table 1) on the X axis.

RESULTS AND DISCUSSION

With the base set of input values (Table 1) and medium-maturing lambs, the estimated feed requirements of each ewe was 536.7kg DM per year, including 165.8kg DM to raise 1.2 lambs to weaning. The total feed consumed in the system per ewe per year, which included feed for one eightieth of a ram and feed to grow lambs to the target weight, was 654kg DM. The average lamb weaning weight was 24.2kg and the average time post-weaning to reach the target weight was 65.5 days. Lambs dressed out at 43.5% to give 15.7kg carcasses which received an average of $339ckg^{-1}$.

Table 3 shows results in terms of "E" and profit values for running the base set of values as Scenario A along with four separate modifications as Scenarios B to E. The same results are shown graphically in Figure 1 with lambing percentage (variable 22 in Table 1) selected as the X variable. The changes in "E" and profit values between Scenarios B to E and the default scenario (Table 3) are in the directions expected, but the program enables the changes to be quickly quantified and characterised.

The information in Figure 1 may be used to estimate the lambing percentage required in order for each of the scenarios to have the same "E" value (Table 3), and also to illustrate any variation amongst scenarios in the pattern of

TABLE 1: Default values of 32 variables used in the efficiency model together with the built-in range for each variable and the corresponding range of "E" (efficiency) values obtained for that variable when all other variables were at default values.

Production Variable	Default value	Range within model	Corresponding "E" range
Ewe-related variables:			
1. Ewe buying price ($/hd)	55	40 to 75	1.46 to 1.27
2. Ewe average live weight (kg)	55	40 to 75	1.40 to 1.33
3. Ewe average carcass value ($/kg)	1.20	1.12 to 1.96	1.36 to 1.43
4. Ewe dressing-out percentage (%)	45	39 to 53	1.36 to 1.39
5. Ewe breeding life (yr)	4	2 to 9	1.22 to 1.49
6. Ewe greasy fleece weight (kg)	4	2.5 to 6.0	1.31 to 1.45
7. Average wool value ($/kg)	2.54	2.00 to 3.75	1.34 to 1.45
8. Ewe overhead costs ($/yr)	4	1 to 8	1.44 to 1.29
9. Ewe mortality (proportion/yr)	0.05	0.02 to 0.09	1.37 to 1.36
Ram-related variables:			
10. Ram price ($/hd)	150	50 to 400	1.38 to 1.34
11. Ram average weight (kg)	70	50 to 120	1.31 to 1.48
12. Ram carcass value ($/kg)	0.04	0 to 0.28	1.37 to 1.37
13. Ram dressing-out percentage (%)	50	44 to 58	1.37 to 1.37
14. Ram breeding life (yr)	2	1 to 8	1.35 to 1.39
15. Ram fleece weight (kg)	5	3.50 to 7.00	1.37 to 1.37
16. Ram overhead costs ($/yr)	2.5	1.00 to 4.50	1.37 to 1.37
17. Ewe to ram ratio	80	40 to 180	1.34 to 1.38
Feed-related variables:			
18. Ewe maintenance requirement (MJ ME /$kgBW^{0.75}$/yr)	200	180 to 215	1.42 to 1.33.
19. Feed for single lamb @ 25kg (MJ ME)	1500	1350 to 1700	1.39 to 1.34
20. Feed cost (c/kg DM consumed)	6	4.5 to 8.0	1.62 to 1.14
21. Feed "quality" (MJ ME/kg DM)	10.5	9.0 to 12.5	1.23 to 1.53
Lamb-related variables:			
22. Lambs marketed/ewe put to ram	1.2	0.80 to 2.20	1.14 to 1.72
23. Lamb final target weight (kg)	36	30 to 51	1.11 to 1.23*
24. Lamb pelt value ($/hd)	5.5	4.0 to 7.5	1.34 to 1.41
25. Lamb fleece weight (kg)	0	0.0 to 1.40	1.37 to 1.44
26. Lamb dressing-out percentage (%)	43	38.5 to 49.0	1.22 to 1.45
27. Lamb weaning weight (single)(kg)	25	22 to 29	1.34 to 1.42
28. Lamb post-weaning ADG (g/day)	180	60 to 340	1.07 to 1.47
29. Lamb overhead costs ($/30d)	2	0.5 to 4.00	1.46 to 1.27
30. Lamb schedule deviation ($/kg)	0	-60 to +80	1.19 to 1.61
31. Lamb maintenance (MJ ME/$(kg\ BW)^{0.75}$/day)	0.6	0.45 to 0.80	1.39 to 1.35
32. Lamb growth requirement parameter	60	30 to 100	1.38 to 1.36

* A maximum "E" value was obtained with a target weight of 36 kg. For all other variables the maximum E was at one or other extreme.strate any variation amongst scenarios in the pattern of

change in "E" with increasing lambing percentage. For example, the fact that curve E diverges from the default curve A to a greater extent than curve B in Figure 1 is due to the fact that an improved post-weaning ADG will become increasingly important as lambing percentage increases. This is because weaning weight declines as there are more twins and, as a result, post-weaning growth becomes a greater proportion of total growth. Similarly, the fact that curves D and C cross over indicates that the negative effect of decreasing the schedule price became proportionately more marked as lambing percentage increased. This can be attributed to the fact that increasing ewe price is a one-off constant effect, while the effects of decreases in lamb prices become larger when more lambs are produced.

The examples in Table 3 and Figure 1 involved the number of lambs marketed per ewe as the X variable and considered scenarios in which only one variable differed from the default scenario. As noted above, any one of the 32 variables in Table 1 can be used as the X variable, and modified scenarios can involve changes in any number of the 32 variables, as well as changes between the three possible lamb-maturing patterns.

The efficiency program described here was developed for use as a teaching aid so that the effect of making various changes or combinations of changes to a system of sheep-meat production could be evaluated quickly and easily. Use of the program decreases the need for tedious calculations and increases the opportunities and time to devise and think through relevant scenarios.

TABLE 2: Equations used to calculate values from the basic input data given in Table 1. Numbers within square brackets in the equations refer to the numbered variables in Table 1.

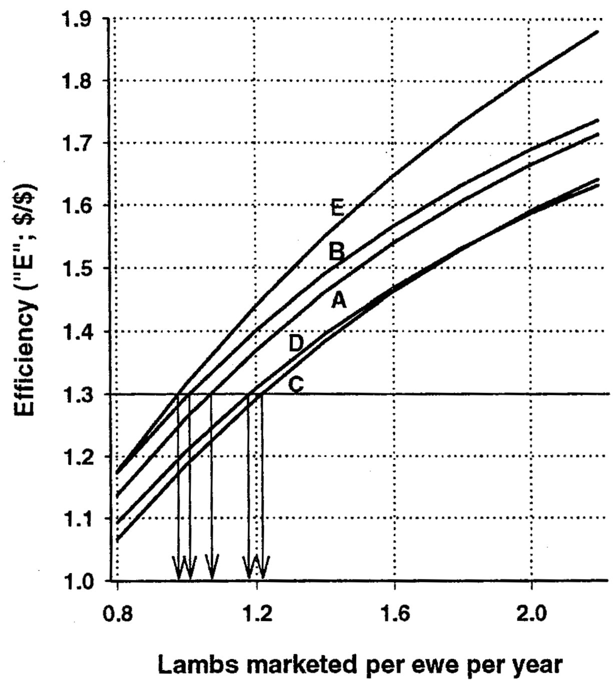
Item being calculated	Equation
Extra feed required over maintenance to cover the feed costs of a ewe and lamb(s) to weaning (ExFeed) (MJ ME)	1. ExFeed = ([27]/25)*[22]* 1500*(1.167-([22]/6) = 1500 MJ ME for a single lamb that is 25kg at weaning.
Weaning weight adjusted so it decreases when more lambs are reared per ewe (AdjWWt)	2. AdjWWt = [27] + 4 – (4*[22]) = 25kg for singles and 21kg for twins.
Lamb feed requirements over maintenance for post-weaning growth (LmbGr)(MJ ME/day)	3. LmbGr = [28]*([32] + (12*BW))/[21] Where BW = live weight (kg)
Dressing-out percentage for lambs, adjusted so that it increases with increasing lamb live weight (DO%)(%)	4. DO% = [26] + 4.69 – (150/FW) = 42% when FW = 32kg Where FW = lamb liveweight at slaughter
Adjustment multiplier of lamb weaning weight and post-weaning growth rate so that these increase with increased mature weight of their parents (AdjFactor)	5. AdjFactor = $(AvWt)^{0.73}/(62.5)^{0.73}$ Where AvWt = average mature weight of the parents, which will be 62.5kg for the default values of 55kg (ewes) and 70kg (rams).

TABLE 3: Results in terms of "E" and profit from running the basic set of default values for Scenario A and four modifications for Scenarios B to E. In addition the lambing percentage required to give an "E" of 1.30 for each scenario is shown. Numbers with the variables changed refer to the item number in Table 1.

Scenario	Efficiency "E" ($ $\$^{-1}$)	Profit ($ ewe^{-1} yr^{-1})	Lambing % to give an "E" of 1.30
A. Default values in Table 1	1.37	23.36	107
B. Wool value (7) increased by 50ckg^{-1}	1.40	25.35	101
C. Ewe price (1) increased by $15	1.29	19.62	122
D. Lamb carcass price decreased 20ckg^{-1}	1.31	19.60	118
E. Lamb post-weaning ADG (28) up 100g	1.44	26.48	98

In developing the program, the aim was to strike a balance between simplicity on the one hand, so that all components could be easily understood, and credibility and accuracy on the other. Aspects that can be criticized as oversimplifications include the use of a single wool price for all wool types, and the use of a single price for the cost of pasture dry matter without any variation between seasons. In both cases, the values used should be considered as weighted averages, and could readily be calculated within a spreadsheet, but it would mean an appreciable increase in the number of variables to be specified if such features were added to the current program.

FIGURE 1: Changes in "E" values ($ income per $ costs) with increasing number of lambs marketed per ewe per year for five scenarios, with one variable changed from the default values (Table 1) in each case.
Line A = The default scenario.
Line B = 50ckg^{-1} increase in wool price.
Line C = $15 increase in ewe price.
Line D = 20ckg^{-1} decrease in lamb carcass prices (across all classes).
Line E = 100gd^{-1} increase in lamb post-weaning ADG.
The vertical arrows show the lambing percentages required for each scenario in order to attain an E value of 1.30.



CONCLUSIONS

The spreadsheet program described here considers a range of variables that can have an impact on the efficiency or profitability of a sheep-meat production system, and provides a simple method of rapidly evaluating the size and nature of these effects. By considering the variables simultaneously, the program facilitates the development of an understanding of how such variables act and interact.

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