TOWARDS OPTIMUM FAT LAMB MATING STRATEGIES ON THE NORTHERN TABLELANDS

Murray A. Johns and Robert A. Pearse*

An attempt was made to quantify some of the variables which affect mating strategies on the Northern Tablelands in the high rainfall zone of New South Wales. A single year linear programming model was developed which permitted the determination of the optimum date of lambing of a Merino X Border Leicester ewe flock (composed of four tooth, six tooth, and full mouth ewes and mated to Dorset Horn rams) for a range of prices and seasonal conditions. It was found first, that generally a staggered lambing is most profitable; secondly, that it pays to lamb early for the Christmas-New Year market if premiums are adequate; and thirdly, that it pays to buy considerable quantities of oaten grain for winter feeding.

1 INTRODUCTION

On the Northern Tablelands of New South Wales there have been rapid increases in improved pasture and fat lamb production over the last decade. This relatively sudden change in the sheep enterprise has not given time for the development of optimum lambing strategies. This paper represents an exploratory study to gain some insight into how the physiological, agronomic and economic factors involved affect these strategies.

The present mating strategy is such that few producers try to exploit the Christmas-New Year market, the bulk of lambs being sold in January-February. Although there appears to be a considerable price differential in premium lamb prices between the Christmas-New Year markets and the January-March markets, production for the Christmas-New Year market is considered a high cost, high risk venture due to the possibility of high neo-natal lamb losses from sudden cold weather in August. Also there is usually a large unfinished tail flock which have to be sold for as little as $4 per head[1]. This is due to animal requirements not being adequately co-ordinated with the pasture availability pattern—spring pasture wastage and an autumn deficit. There also appears to be misallocation of labour on small holdings,

* Mr Johns is now at the Bureau of Agricultural Economics, Canberra. The work reported formed part of his final year thesis at The Faculty of Agricultural Economics, U.N.E. Dr Pearse is Senior Lecturer in Farm and Business Management, University of New England, Armidale, N.S.W. He formulated the linear programming model and supervised the research.

[1] This has also been reported in fat lamb breeding comparison trials in South Australia at the Kybybolite Research Centre. See R. A. Anderson, "Fat Lamb Breeds Comparison Trial", *Journal of Agriculture* (South Australia), Vol. 62, No. 5 (December, 1958).

because if all ewes (say 800) were to be mated together (a common practice) it would prove difficult for one man to adequately supervise the breeding flock at lambing time. It may possibly be advantageous to employ a staggered lambing technique, which would ease the intensity of labour demands as well as the pressure on pasture availability, at the expense of added concern due to a longer lambing period.

2 THE MODEL

In this study the technique employed is single stage linear programming because it readily handles the numerous activities of time of lambing by age of ewe, subject to the availability of feed, labour, and mortality restraints. Polyperiod programming would enable one to examine the effect of varying seasons on flock structure. However since many of the coefficients were difficult to quantify, it was considered that the compounding of errors would negate the possible advantage of a study over time. Further, it is difficult to accurately predict seasonal prices in a long term model and to specify the appropriate seasonal feed supplies.

2.1 THE BASIC MODEL EXPLAINED

(i) *The basic assumptions of the model*

The three basic assumptions of the model are as follows. First, that spring lambing is practical using fat lamb sires (e.g. Dorset Horns) over first cross Merino ewes (e.g. Border Leicester X Merino). Secondly, that there is a high level of both breeding flock and pasture management. Thirdly, it is assumed that improved pasture (e.g. phalaris and white clover) yielding approximately 4,500 lb of dry digestible organic matter (D.O.M.) per acre per annum is supplemented with winter grazing oats yielding approximately 400 to 600 lb D.O.M. per acre per month from May to October inclusive.

(ii) *The activities included in the model*

Four types of variables concerned with (a) ewes, (b) feed, (c) lambs, and (d) labour make up the activities in the model. They are presented in Table 1 together with the objective function.

(iii) *The restraints or rows of the model*

The restraints used also encompass (a) ewes, (b) feed, (c) lambs, and (d) labour, and are presented in Table 2.

(iv) *Variation of the data used in the model*

The coefficients in the objective function, matrix and right hand sides all may be varied to enable the model to have the flexibility to meet differing situations. Coefficients which one might vary are labour supply, pasture growth and production in the various seasons, ewe fertility, fat lamb prices, ewe replacement prices, feed costs, weather patterns (as affecting lamb mortality), levels of husbandry, etc. The main parameters varied in this study are lamb prices and feed availability.

TABLE 1

Activities used in the Linear Programmes

Activities	Unit	*$—c*
Ewe Activities—		
Four tooth ewe-lambing in the first half of July ..	ewe	
Four tooth ewe-lambing in the second half of July	,,	
Four tooth ewe-lambing in the first half of August	,,	
Four tooth ewe—lambing in the second half of August and similarly for September, October and November	,,	
Six tooth ewe—10 activities as for four tooth ewes ..	,,	
Full mouth ewe—10 activities as for four tooth ewes	,,	
Ewe supply to first half of July for each ewe type representing purchase of the cross bred ewe	,,	—$5.50
Four tooth ewe—transfer from 1st half of July to 2nd half of July	,,	
Four tooth ewe—transfer from 2nd half of July to 1st half of August	,,	
Four tooth ewe—transfer from 1st half of August to 2nd half of August	,,	
and similarly to 1st half of November to 2nd half November	,,	
Six tooth ewe—9 transfer activities as for four tooth ewe	,,	
Full mouth ewe—9 transfer activities as for four tooth ewe	,,	
Four tooth ewe supply to replace losses due to deaths & culls	,,	—$10.00
Six tooth ewe supply to replace losses due to deaths & culls	,,	—$8.00
Full mouth ewe supply to replace losses due to deaths	,,	—$6.00
Cull activity to cull half of full mouth ewes—ewe has four year life in the flock	,,	$4.00
Feed Activities—		
Transfer from early spring to late spring	LSM	
Transfer from late spring to early summer	,,	
Transfer from early summer to late summer ..	,,	
Transfer from late summer to early autumn ..	,,	
Transfer from early autumn to late autumn	,,	
Transfer from late autumn to early winter	,,	
Transfer from early winter to late winter	,,	
Purchase of feed to supply early winter	bushel oats	—$0.70
Purchase of feed to supply late winter	,,	,,
Lamb Activities—		
Sale of lambs from each of four lamb pools ..	Lamb	$5.00–$9.00
Labour Activities—		
Five activities to supply each of July to November labour pools with labour at $1.50/hour	hour	—$1.50

TABLE 2

Restraints used in the Linear Programmes

Restraint	Unit	1
Ewe Restraints—		
10 four tooth ewe supply pools—1st half of July to 2nd half November	ewe	0
10 six tooth ewe supply pools—1st half of July to 2nd half November	,,	0
10 full mouth ewe supply pools—1st half of July to 2nd half November	,,	0
Four tooth ewe pool—supply of ewes after deaths and culling	,,	0
Six tooth ewe pool—supply of ewes after deaths and culling	,,	0
Full mouth ewe pool—supply of ewes after deaths ..	,,	0
Four tooth equality row to purchase replacements for deaths & culls	,,	0
Six tooth equality row to purchase replacements for deaths & culls	,,	0
Full mouth equality row to purchase replacements for deaths	,,	0
Full mouth row to force culling of half full mouth ewes	,,	0
Fat Lamb Pools—		
Four pools, each supplied by one or more breeding activities to permit four price strategies	lamb	0
Feed Pools—		
Early spring	LSM	2,903
Late spring	,,	4,173
Early summer	,,	2,721
Late summer	,,	2.475
Early autumn	,,	2.310
Late autumn	,,	1,121
Early winter	,,	784
Late winter	,,	1,070
Labour Pools—		
July	man hours	160
August	,,	160
September	,,	160
October	,,	160
November	,,	160

3 THE MATRIX COEFFICIENTS

The model discussed above permits the expression of many of the variables which affect optimum time of lambing. These variables are:

(1) the probability of a ewe conceiving;

(2) the lambing percentages obtained;

(3) the probability of ewe survival in the flock;

(4) ewe purchase;

(5) feed production and the feed requirements of the flock;

(6) the labour requirements of the flock when lambing;

(7) the time of sale of lambs and the price received.

Details of the derivation of these co-efficients are presented in the appendix; results are shown in Tables 3 to 6.

TABLE 3

The Probability of a Border Leicester X Merino Ewe Supplying a Lamb to the Lamb Pool in Each of the Lambing Periods

Age of the ewe	July		August		September		October		November	
	J1	J2	A1	A2	S1	S2	O1	O2	N1	N2
Four Tooth ..	0·606	0·655	0·714	0·732	0·784	0·802	0·79	0·701	0·595	0·460
Six Tooth ..	0·636	0·753	0·851	0·908	0·966	0·981	0·966	0·863	0·737	0·551
Full Mouth ..	0·667	0·852	0·989	1·049	1·110	1·123	1·106	0·993	0·795	0·598

TABLE 4

The Ewe Supply Coefficients for the Ewe Survival Pools

Age of the ewe	July		August		September		October		November	
	J1	J2	A1	A2	S1	S2	O1	O2	N1	N2
Four Tooth ..	0·750	0·809	0·853	0·875	0·883	0·867	0·855	0·792	0·693	0·561
Six Tooth ..	0·768	0·828	0·873	0·895	0·905	0·887	0·874	0·809	0·708	0·573
Full Mouth ..	0·759	0·819	0·863	0·835	0·895	0·877	0·864	0·800	0·701	0·567

TABLE 5

Feed Provided to each Feed Pool from 300 *acres of Phalaris-White Clover Pasture and* 20 *acres of Oats*

Feed pool	Livestock months	Feed pool	Livestock months
Autumn A ..	2,310	Spring A ..	2,903
Autumn B.. ..	1,121	Spring B	4,173
Winter A	784	Summer A ..	2,721
Winter B	1,070	Summer B ..	2,475

TABLE 6

Feed Requirements for One Ewe and Followers entering the Plan over given range of Lambing Times

	J1	J2	A1	A2	S1	S2	O1	O2	N1	N2
	Four Teeths									
Au. A	1·65	1·65	1·65	1·65	1·65	1·57	1·49	1·29	1·14	1·40
Au. B	1·75	1·70	1·65	1·65	1·65	1·65	1·65	1·65	1·48	1·17
Wi. A	3·05	2·40	2·00	1·75	1·70	1·65	1·65	1·65	1·65	1·65
Wi. B	2·57	3·31	3·61	3·05	2·40	2·00	1·75	1·70	1·65	1·65
Sp. A	3·07	3·23	3·35	3·35	3·50	3·33	3·05	2·40	2·00	1·75
Sp. B	1·87	2·70	3·53	3·58	3·53	3·41	3·28	3·27	3·11	3·05
Su. A	1·37	1·32	1·41	2·18	2·96	3·59	3·49	3·17	2·73	2·16
Su. B	1·65	1·65	1·57	1·51	1·44	1·41	2·13	·265	2·87	2·28
	Six Teeths									
Au. A	1·65	1·65	1·65	1·65	1·65	1·58	1·51	1·32	1·14	1·42
Au. B	1·75	1·70	1·62	1·65	1·65	1·65	1·65	1·65	1·48	1·17
Wi. A	3·05	2·60	2·20	1·95	1·70	1·65	1·65	1·65	1·65	1·65
Wi. B	2·94	3·35	3·34	3·05	2·60	2·20	1·95	1·70	1·65	1·65
Sp. A	3·13	3·31	3·43	3·43	3·55	3·35	3·05	2·60	2·20	1·95
Sp. B	1·91	2·77	3·61	3·65	3·61	3·49	3·35	3·31	3·13	3·05
Su. A	1·39	1·75	1·44	2·23	3·01	3·67	2·58	3·23	2·79	2·19
Su. B	1·65	1·65	1·58	1·53	1·47	1·44	2·18	2·70	2·93	2·34
	Full Mouths									
Au. A	1·65	1·65	1·65	1·65	1·65	1·58	1·49	1·32	1·14	1·41
Au. B	1·95	1·70	1·65	1·65	1·65	1·65	1·65	1·65	1·48	1·17
Wi. A	3·05	2·60	2·20	1·95	1·70	1·65	1·65	1·65	1·65	1·65
Wi. B	2·90	3·33	3·32	3·05	2·60	2·20	1·95	1·70	1·65	1·65
Sp. A	3·10	3·26	3·40	3·40	3·53	3·34	3·05	2·60	2·20	1·95
Sp. B	1·88	2·73	3·56	3·62	3·58	3·46	3·32	3·29	3·12	3·05
Su. A	1·37	1·35	1·41	2·20	2·99	3·62	3·52	3·20	2·76	2·13
Su. B	1·65	1·65	1·57	1·51	1·47	1·44	2·14	2·68	2·90	2·31

4 RESULTS FROM VARYING THE FEED AND PRICE PARAMETERS

Two sets of conditions are considered with varying price combinations—average seasonal conditions and for seasonal conditions.

4.1 AVERAGE SEASONAL CONDITIONS

The results obtained are presented in Table 7. Note that no lambings occur in J1, J2, A1 or N2. Run 1 assumes that the price remains at $6.50 over the whole selling period. The number of ewes carried is 225 : 225 : 450 or a total of 900[2]. Three lambing periods are selected, namely S2, O1, and N1; the youngest ewes being mated latest and the full mouths earliest. Such a pattern is more or less evident throughout Table 7, although the lambing dates differ. It is clear that even if prices do not change, it pays to stagger lambing dates for agronomic or labour

[2] The table indicates that 907 ewes were joined. The additional seven represent ewes which did not conceive when first joined and which were again joined in a subsequent period.

TABLE 7

Optimum Lambing Strategies for Varying Price—Average Seasonal Conditions

Run No.	Lamb price and ewe ages	Lambing period						
		August		September		October		November
		A1	A2	S1	S2	O1	O2	N1
1	Lamb Price .. .. $	6.50	6.50	6.50	6.50	6.50	6.50	6.50
	Four Tooth	..	..	..	..	145	..	87
	Six Tooth	..	..	..	..	225	..	
	Full Mouth	..	..	..	410	40	..	..
	No. Joined	..	..	..	410	410	..	87
2	Lamb Price .. .. $	7.00	7.50	7.00	7.00	6.50	6.50	..
	Four Tooth	..	..	..	..	201	..	32
	Six Tooth	..	13	..	..	209	..	..
	Full Mouth	..	..	..	445	..	..	..
	No. Joined	..	13	..	445	410	..	32
3	Lamb Price .. .. $	7.00	8.00	7.00	7.00	6.00	6.00	5.00
	Four Tooth	..	..	..	172	41	..	..
	Six Tooth	..	213	..	..	..	..	..
	Full Mouth	..	188	..	238	..	..	..
	No. Joined	..	401	..	410	41	..	..
4	Lamb Price .. .. $	7.00	9.00	7.00	7.00	6.00	6.00	5.00
	Four Tooth	..	..	..	212	..	..	..
	Six Tooth	..	212	..	..	..	..	..
	Full Mouth	..	424	..	..	..	..	..
	No. Joined	..	636	..	212	..	..	..
5	Lamb Price .. .. $	7.00	10.00	7.00	7.00	6.00	6.00	5.00
	Four Tooth	..	212	..	..	..	..	..
	Six Tooth	..	212	..	..	..	..	..
	Full Mouth	..	424	..	..	..	..	..
	No. Joined	..	848	..	..	..	..	..
6	Lamb Price .. .. $	8.00	8.00	8.00	8.00	7.00	7.00	6.00
	Four Tooth	..	..	..	20	200	..	..
	Six Tooth	..	..	..	..	220	..	..
	Full Mouth	..	..	..	440	..	..	..
	No. Joined	..	..	..	460	420	..	..

reasons. Some 90 per cent of lambs are produced for the January-February market. Labour was limiting in both September and October. There was surplus feed in spring, which was transferred to summer; in autumn about 50 per cent of the feed was transferred to winter. Even so it was profitable to purchase 1,400 bushells of oats. Note that although labour and possibly feed requirements prevented all ewes being mated in April (the period of greatest fertility), it did not pay to hire labour at $1.50 per hour. To summarise, with price unchanging, it is best to stagger lambing dates, to aim for a fairly high ewe fertility period, to buy considerable amounts of feed, and not hire labour.

In the second run (Run 2) prices vary with up to a dollar premium for the Christmas-New Year market, a 50 cent increase for January and a drop of 50 cents for late March sales. Some 890 ewes were run, 10 less than with stable prices. All the full mouths lambed in S2, while some 50 fewer young ewes lambed in N1 where prices were declining. The premium price for Christmas had little effect, with only 13 being mated to supply the market, too few to be of practical significance. Fourteen hours of labour were hired to permit all the full mouths to lamb in September. The pattern of feed transfers and feed purchase were similar to those in the first run.

In the third run (Run 3) prices for Christmas were raised a further 50 cents and prices late in the season dropped by 50 cents. The new price regime caused major changes in the lambing strategy as about 48 per cent of ewes were joined for the Christmas market. Interestingly this group constituted all the six tooth ewes and about half of the full mouths. The majority of the young ewes then lambed in S2. The number of ewes carried dropped to 852 and the amount of feed bought rose to 1,625 bushells. Feed was transferred within spring and from summer to autumn. Although labour was limiting in both August and September it was not profitable to employ casual labour. To test the effect of the 50 per cent feed deterioration factor, this price combination was run using a 25 per cent deterioration, which might be achieved with skilled management. The result was a considerable increase in feed transfer, a 50 per cent reduction in grain purchase, and all ewes lambing in August and September.

In the fourth and fifth runs (Run 4 and Run 5) prices were as in Run 3 except that an additional one and two dollar margin for the Christmas-New Year market was considered. Ewe numbers remained about 850 but grain purchases increased, as did casual labour costs. In Run 4 labour costs increased by $139.50 whilst the gross margin increased by $164.00 or 3 per cent over the gross margin of Run 3, supporting the graziers' contention that early lambing may be high cost and low profit. In Run 5 labour costs rise by $267 but the gross margin rises by $894.00 or 18 per cent. Run 5 with the very high premium price is the only run in which it did not pay to stagger lambing.

In the sixth run (Run 6) the price slowly dropped over the sale period from $8.00 to $6.00. Ewe numbers were intermediate between those of Runs 1 and 2 and Runs 3–5. The full mouths all lamb in S2 and the younger ewes in O1. We should note a deficiency in the model in that to conserve space only monthly labour pools were used, it being assumed that some transferability of over-time within the month could be permitted. However in the approximate four weeks period S2-01 the whole labour availability of September and October is required, plus 23 hours of hired labour in September.

4.2 POOR SEASONAL CONDITIONS

The results obtained using "poor" seasonal conditions are presented in Table 8, the price regimes being those of Runs 2, 3, and 6. A "poor" season is defined as one in which feed availability is 30 per cent less than in a normal year. In the seventh run (Run 7) the prices are as in Run 2 but the late spring and early summer feed pools have been reduced by 30 per cent to simulate a poor late spring and early summer. The number of ewes carried declines from 890 to 690, ten times as many ewes lamb in A2 and only a third as many in O1. There is need for the purchase of about 530 bushells of oats, but no casual labour is required. Thus the response to the changed seasonal conditions is reflected both in lambing strategy and in the number of ewes carried.

TABLE 8

Optimum Lambing Strategies for Prices Related to Simulated Poor Seasons

Run No.	Lamb price and ewe ages	Lambing period						
		August		September		October		November
		A1	A2	S1	S2	O1	O2	N1
				Poor late Spring and Summer				
7	Lamb Price .. .. $	7.00	7.50	7.00	7.00	6.50	6.50	6.00
	Four Tooth	..	..	..	30	142	..	..
	Six Tooth	..	..	..	172	..	..	..
	Full Mouth	..	140	..	206	..	..	..
	No. Joined	..	140	..	408	142	..	..
				Poor Winter and early Spring				
8	Lamb Price .. .. $	7.00	8.00	7.00	7.00	8.00	6.00	5.00
	Four Tooth	..	..	..	164	..	..	..
	Six Tooth	..	164	..	..	..	..	..
	Full Mouth	..	84	..	244	..	..	..
	No. Joined	..	248	..	408	..	..	..
				Poor late Winter and Spring				
9	Lamb Price .. .. $	8.00	8.00	8.00	8.00	7.00	7.00	6.00
	Four Tooth	..	..	..	..	..	159	..
	Six Tooth	..	..	..	..	159	..	..
	Full Mouth	..	..	..	318	..	..	..
	No. Joined	..	..	..	318	159	159	..

In the eighth run (Run 8) the prices are as in Run 3, the premium being justified by the assumption of a poor late winter and early spring represented by a 30 per cent reduction in these feed pools. Again about 200 fewer ewes are run but S1 lambing is virtually unchanged, the reduction being in the number lambing in A2. Thus the increase in premium does not make it profitable to hold the August lambing at the level profitable in an average season. It is to be noted that twice as many six tooth as full mouth ewes are mated to lamb in A2, one of the few times we note a substantial majority of the young ewes being mated prior to the full mouths. The ewe numbers are sufficiently reduced so that no casual labour is required. The spread is such that no excessive demands would be placed on family labour as occurs with an S2-O1 lambing strategy. Feed transfers are such that considerable skill would be necessary in manipulating the available feed supplies.

In the final run (Run 9) the prices are those of Run 6 but a poor late winter and spring are assumed. The changed feed supply results in each age group lambing in successive periods, beginning with S2. In Run 3 the full mouths lambed in S2 and all the young ewes in O1. The decline in ewe numbers is the greatest observed, falling from 880 to 636. Generally the effect of postulating a period of reduced pasture production is to produce a somewhat more even spread of lambing than is indicated for an average season. On the other hand, if a grazier anticipated a poor season, he might argue that he has more than enough managerial problems without the additional strain of coping with a staggered lambing.

4.3 GENERAL DISCUSSION OF THE RESULTS

The foregoing results show that even in a poor season it may be profitable to exploit a premium market for fat lambs. The premium must, however be sufficient to cover the increased feed and labour costs, the much greater skill required to manipulate the available feed production and the mating of ewes at a period of less than maximum fertility which are entailed. The results also suggest that for profit maximization considerable skill in manipulating the available feed supplies is necessary because feed transfers, other than the anticipated autumn-winter transfer, are present at substantial levels. The model indicates further that the purchase of substantial quantities of supplementary feed is profitable. Such feeding however, may require a substantial investment in storage facilities unless off farm feed supplies are readily available.

As noted, the labour requirements are not always fairly reflected in the model, but it does seem that quite often the M.V.P. of casual labour is not equal to its probable cost. This is not true when there are markets available with a very high premium price. Thus from a labour point of view it would seem reasonable to suggest that it is more profitable to stagger lambing times than it is to employ casual labour for ewe supervision, unless a premium market is available.

5 CONCLUSIONS

The present lambing strategy, which has the dual objective of utilizing the peak fertility of the ewe and minimising the length of the lambing period, does not fit the pattern of feed supply generated by the oat crop and pasture, nor does it necessarily fit in with labour supplies and premium prices. The lack of a staggered lambing can result in insufficient quality feed for the lambs when they "finish", causing a large "tail" which must be sold at well below quality fat lamb prices. By considering the economic and agronomic factors, as well as the physiologic factors, it is evident that a strong case can be presented for staggered lambing dates. An August lambing considerably reduces the stress on pastures, also the analysis of meteorological data suggests that, as there are roughly equal probabilities of high lamb loss in both August and September, the risk of "cold snap" losses should not deter a grazier from lambing in August. The evidence suggests that despite slightly lower lambing percentages there is an economic gain to be derived by using staggered lambing dates.

It would seem that there are a number of questions raised by this tentative examination of the problem. A major one is that of flock composition and the number of ewes to be carried. There was a suggestion that the older ewes are most profitable, but are there any practical ways of obtaining a flock composed solely of four to five year old ewes? What level of stocking should be used, given that a reduction in the availability of spring feed supplies reduces ewe numbers by 200 or more? A possible way of examining these problems would be by the use of simulation, especially if one were concerned with the effect of seasonal changes on the economics of flocks of a given size. It would be useful also in testing the effects of small changes in some of the coefficients which are least precisely quantified. Another method which might shed some light on the flock composition problem would be the use of polyperiod programming. As with simulation, one could get a reasonable estimate of income flows over time and an appreciation of feed deficit periods. It would also have the advantage of providing the marginal values of limiting resources. Certainly in later studies the problem of labour supplies and labour coefficients would require close attention.

APPENDIX

DERIVATION OF THE MATRIX COEFFICIENTS

The model discussed above allows the expression of many of the variables which affect optimum time of lambing. We will now discuss in more detail the nature of these variables and how they may be expressed in the model, using the following subheadings:

(1) The probability of a ewe conceiving.

(2) The lambing percentages obtained.

(3) The probability of ewe survival in the flock.

(4) Ewe purchase.

(5) The amount of feed available, and the feed requirements of the flock.

(6) The labour requirements of the flock when lambing.

(7) The time of sale of lambs and the price received.

1 THE PROBABILITY OF A EWE CONCEIVING

The probability of a ewe conceiving is a function of the combined probabilities of the ewe exhibiting oestrus and of her being served by a fertile ram. The ewes of different ages are assumed to be equally likely to exhibit oestrus at a given period as they are assumed to be healthy and well fed. The probability of a Border Leicester X Merino ewe coming into oestrus at a given date between February and June was taken from data published by Brunskill[1]. The probability of a ewe being served by a fertile ram is a function of mating percentage, libido, health, nutrition, and temperature. The latter should not be a problem on the Northern Tablelands, and most of the former should be covered by the assumption of good management leaving hormonal balance as governed by the time of year being the main factor of concern. The probability of the ewe being served by a fertile ram was again taken from Brunskill[2]. The combined probabilities of ewe conception over the February-June period are presented in Table 1. In the ewe breeding activity the probability that a ewe will *not* conceive is used to supply the next breeding period but one i.e. if 100 ewes were joined in early February it is probable that some 14 of them would not conceive. These 14 would be made available for mating in March. The probability of a ewe not conceiving was calculated as being:

TABLE I

Probability of a Ewe Conceiving Over the Given Range of Mating Times

F_{-1}	F_{-2}	M_{-1}	M_{-2}	A_{-1}	A_{-2}	M_{-1}	M_{-2}	J_{-1}	J_{-2}
·863	·931	·97	·995	·995	·975	·95	·88	·762	·617

1 A. Brunskill, "Oestrus and the Breeding Season in the Ewe", *Agricultural Gazette*, Vol. 80 (April 1969).

2 *Ibid*, p. 215.

Probability of a Ewe Not Conceiving over a Range of Mating Times

February		March		April		May		June	
F1	F2	M1	M2	A1	A2	M1	M2	J1	J2
·137	·069	·03	·005	·005	·025	·05	·12	·238	·383

2 LAMBING RESULTS

The lambing percentage obtained from a ewe is a function of the probability of conception, the number of eggs released at the ovulation preceding service, the probability of ewe survival, the probability of abortion, and the probability of the lamb(s) surviving until tailing. The lamb percentages make allowance for the ovulation and mortality rates of ewes of differing ages. Experimental data from South Australia[3] was combined with data obtained from local producers on ewe and lambs mortality, proportion of barren ewes, and differences between maiden and mature ewes. Few producers keep accurate records and as most join their ewes between March and April, which meant some extrapolation for the other dates, it is probable that there would be some variation around the estimates made. Local data for ovulation rates for Dorset Horn and Merino ewes were available from a stocking rate and time of lambing trial at the CSIRO Research Station "Chiswick" located near Armidale[4]. Table II shows the ovulation rates used. Ewe deaths and barren ewes, on a commercial basis, seem to run at about five per cent, which is not inconsistent, with experimental findings, for September lambings. Adjustment of these figures for the increased stress of pre-September lambings is necessary. The actual figures for deaths and barren ewes used in the study are presented in Table 3.

TABLE II

Percentage Ovulations per Ewe Over the Given Range of Mating Times

	F_{-1}	F_{-2}	M_{-1}	M_{-2}	A_{-1}	A_{-2}	M_{-1}	M_{-2}	J_{-1}	J_{-2}
4T	105	105	110	110	115	120	120	115	110	105
6T	105	115	125	130	135	140	140	135	130	120
FM	110	130	145	150	155	160	160	155	140	130

TABLE III

Probability of a Ewe Surviving and Giving Birth to a Lamb Over Given Range of Lambing Times

	J_{-1}	J_{-2}	A_{-1}	A_{-2}	S_{-1}	S_{-2}	O_{-1}	O_{-2}	N_{-1}	N_{-2}
4T	·87	·87	·88	·88	·89	·90	·90	·90	·91	·91
6T	·89	·89	·90	·90	·91	·92	·92	·92	·93	·93
FM	·88	·88	·89	·89	·90	·90	·91	·91	·92	·92

[3] R. A. Anderson, *op. cit.*

[4] J. M. George, (personal communication).

The CSIRO, South Australian and local producer data suggest that a lamb mortality of 15 per cent is a reasonable estimate. Inclement weather may cause greater than usual losses[5] and is the reason given by New England graziers for not lambing before September. Obst and Day[6] have presented experimental data on the effect of inclement weather on Merino and Corriedale lamb losses, showing that both wind speed and rainfall combine to increase losses over the 15 per cent level. Twice daily wind and rainfall records at Armidale have been used to estimate the probabilities of losses in each month from inclement weather, see Table IV. Additional losses of up to eight per cent may occur, suggesting that the penalties for early lambing may not be as great as has been anticipated. Because lamb losses are affected by behavioural, as well as physiologic failure allowances have been made between the differing age components for mothering ability. (See Table V for the lamb survival probabilities used.)

TABLE IV

Probabilities of Lamb Mortalities Due to Inclement Weather

(a) Likely per cent Deaths due to Rainfall and Wind Speed Combinations for Newly Born Lambs for BL X M Ewes.

Rainfall (pts)	0–2		>2–<5		5–10		>10–<15		≥15	
0	0	(1)*	2	(4)	3	(7)	6	(10)	9	(13)
>0–20	3	(2)	6	(5)	10	(8)	13	(11)	15	(14)
>20	13	(3)	18	(6)	23	(9)	32	(12)	40	(15)

* Combination number in brackets.

[5] G. Alexander, "Lamb Survival: Physiological Considerations", *Proceedings of the Australian Society of Animal Production*, Vol. 5, (August, 1964).

[6] J. M. Obst and H. R. Day, "Effect of Inclement Weather on the Mortality of Merino and Corriedale Lambs at Kangaroo Island", *Proceedings of the Australian Society of Animal Production*, Vol. VIII (1968), p. 239.

(b) Expected Percentage Neo Natal Lamb Losses from Inclement Weather—Monthly Basis.

Combination No.	Per cent loss due to comb.	July		August		September		October		November	
		P (Comb. occur)*	Expected loss	P (Comb. occur.)	Expected loss	P (Comb. occur.)	Expected loss	P (Comb. occur.)	Expected loss	P (Comb. occur.)	Expected loss
1	0	·3709	·0	·2661	·0	·2366	·0	·1105	·0	·1055	·0
2	3	·0483	·1449	·0268	·0804	·0084	·0252	·0080	·0240	·0194	·0582
3	13	·0134	·1742	·0134	·1742	·0028	·0364	·0213	·2795	·0166	·2518
4	2	·1182	·2364	·1478	·2956	·1352	·2704	·1617	·3234	·1416	·2832
5	6	·0430	·2580	·0295	·1770	·0366	·2196	·0431	·2586	·0277	·1662
6	18	·0080	·1440	·0161	·2898	·0169	·3042	·0242	·4356	·0277	·4986
7	3	·0672	·2016	·1021	·3063	·1154	·3462	·1347	·4041	·1833	·5499
8	10	·0349	·3490	·0510	·5100	·0338	·3380	·0592	·5920	·0611	·6110
9	23	·0134	·3082	·0161	·3703	·0169	·3887	·0188	·4324	·0472	1·0856
10	6	·0537	·3222	·0967	·5802	·1690	1·0140	·1872	1·0992	·1861	1·1166
11	13	·0322	·4186	·0779	1·0127	·0535	·6955	·0619	·8047	·0472	·6136
12	32	·0134	·4288	·0107	·3424	·0281	·8992	·0215	·6880	·0444	1·4208
13	9	·0725	·6525	·0591	·5319	·0929	·8361	·0943	·8487	·0694	·6246
14	15	·0806	1·2090	·0430	·6450	·0309	·4635	·0323	·4845	·0050	·0750
15	40	·0295	1·1800	·0430	1·7200	·0225	·9000	·0242	·9680	·0166	·6640
			6·0274		7·0358		6·7370		7·6427		7·9831

* P (Comb. occur.) means the probability of the given rainfall and windspeed combination occurring in the given month.

The data presented in this and the previous section are combined to calculate the coefficients for lamb supply to the lamb pools by the different breeding ewe activities. The results are shown in Table 3 (text).

3 EWE SURVIVAL

The probability of ewe survival in the flock is a combination of her probability of conceiving and of her surviving being culled for being a barren ewe. The coefficients used for ewe survival in supplying the survival pools are shown in Table 4 (text).

TABLE V

Probability of Survival for Lambs Born to BL X M Ewes

	J_{-1}	J_{-2}	A_{-1}	A_{-2}	S_{-1}	S_{-2}	O_{-1}	O_{-2}	N_{-1}	N_{-2}
4T	·77	·77	·76	·76	·77	·77	·77	·77	·78	·78
6T	·79	·79	·78	·78	·79	·79	·79	·79	·80	·80
FM	·80	·80	·79	·79	·80	·80	·80	·80	·81	·81

4 EWE PURCHASE

There are two types of ewe purchase activity, namely that activity which purchases the ewe flock and those activities which calculate the cost of ewe replacements for deaths, to keep the postulated 1 : 1 : 2 ratio of four tooth, six tooth, and full mouths. The ratio is merely a convenient way of accounting for the cost of deaths, it has no deeper significance, although the earlier suggestion that full mouths are most profitable may indicate that one should attempt to keep as many older sheep as possible.

5 FEED

The amount of feed available and the feed requirements of the flock are considered separately.

(a) *Feed availability.* Three possible sources of feed may be used to supply the feed requirements in a given month. First, the weekly production from 300 acres of a white clover-phalaris pasture producing an average of 4,500 lb of D.O.M. per annum. Secondly, twenty acres of grazing oats, yielding from 400–600 lb of D.O.M. per acre per month from May to October are available to help fill the winter feed gap. The pasture[7] and oats[8] feed output used are presented in Table VI. Thirdly, there is the possibility of buying grain oats for supplementary feeding, in either of the two winter periods, at a cost of $0.70 per bushel.

In the model feed is presented as L.S.M.[9] (livestock months) in each of the eight 6·5 week feed pools. An L.S.M. is equivalent to about 80 lb of D.O.M., and the conversions from D.O.M. to L.S.M. are shown in Table VII. The feed supplied by the 300 acres of pasture and 20 acres of oats, for each feed period, is shown in Table 5 (text). Additional feed may be supplied by purchased oat grain, of which one bushel is equivalent to an L.S.M. Feed may be transferred from one period to another with a constant deterioration of 50 per cent in the pasture quality.

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7 A. Wright, Research Fellow, Department of Farm Management, U.N.E. (private communication). The data is based on a simulation studied carried out using 20 years of rainfall data.

8 These are direct estimates obtained from the Agronomy Department, University of New England.

9 An L.S.M. is the amount of feed required to maintain a 100 lb non pregnant, non-lactating ewe for one month under field conditions.

TABLE VI

Pasture Production Estimates in lb Dry Organic Matter

Average weekly pasture production for Phalaris White Clover—per acre				Expected monthly production from winter grazing oats—per acre	
Week	Production	Week	Production	Month	Production
1 (1–7 July)	19·0	27	127·8	May	200
2	17·5	28	103·2	June	500
3	19·5	29	99·8	July	800
4	18·2	30	108·1	August	600
5	38·8	31	113·4	September	800
6	39·8	32	83·9	October	600
7	36·5	33	93·1		
8	39·9	34	119·9		
9	36·8	35	116·7		
10	86·2	36	117·7		
11	87·0	37	87·1		
12	87·0	38	96·5		
13	87·4	39	83·6		
14	179·8	40	92·7		
15	170·0	41	66·9		
16	200·1	42	67·6		
17	170·2	43	68·0		
18	169·1	44	31·7		
19	179·7	45	71·8		
20	155·9	46	33·7		
21	160·4	47	41·0		
22	135·4	48	34·7		
23	115·4	49	22·6		
24	111·3	50	25·9		
25	106·2	51	28·6		
26	86·4	52	26·2		

(b) *Feed requirements.* The basic data for feed requirements was taken from Rickards[10] but was modified to allow for multiple followers and for "steaming up" prior to lambing. The ewe requirements were further modified to take into account ewe deaths and the possibility of non-conception, where the ewe will be joined in a later time period. The actual requirements are shown in Table 6 and the ewe requirements are shown in Figure I. These requirements also take account of feed requirements for the rams. The possibility of a mistiming of feed supply requirements is shown in Figure I where the monthly feed supply of the pasture and oats combination is compared with the requirements of three breeding ewes lambing in September. The pasture deficiency when one should be attempting to "finish" the lambs for sale is quite evident.

10 P. A. Rickards, "Energy Requirement for Sheep and Cattle" (paper presented to school for farm management consultants, January, 1968).

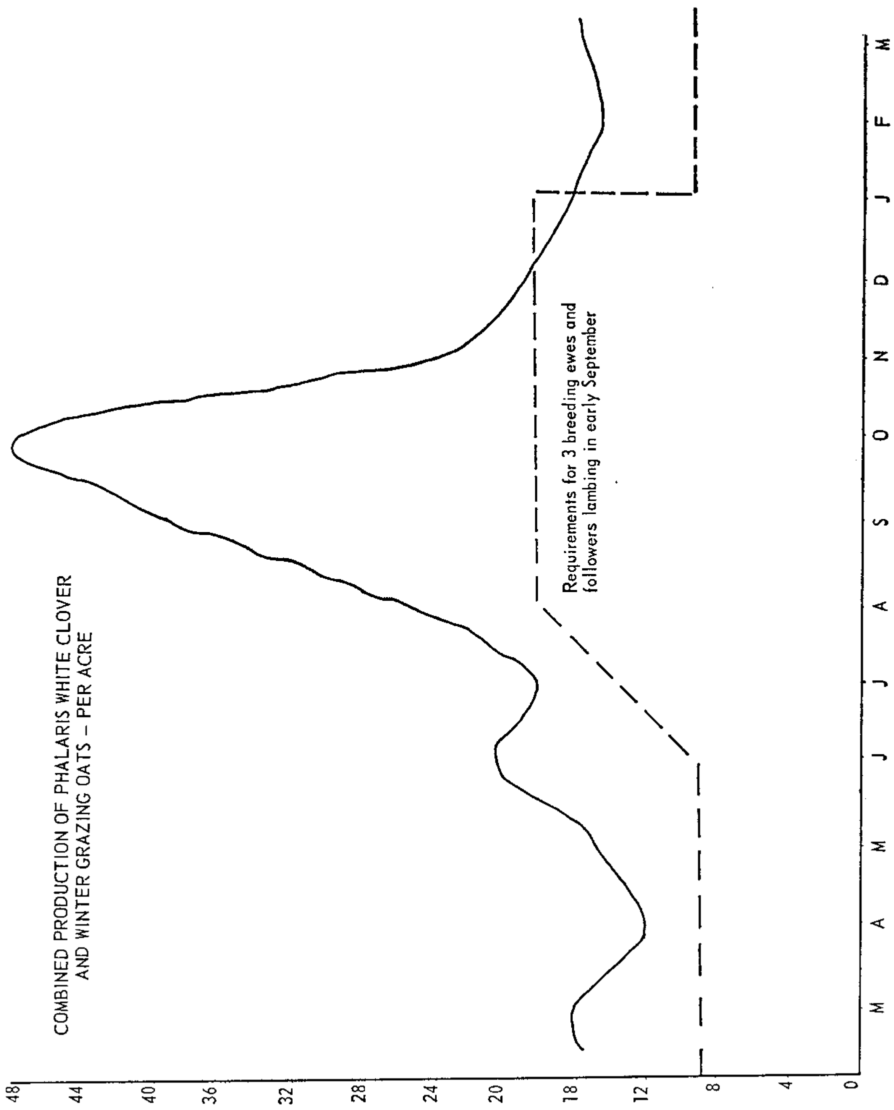
TABLE VII

Feed Availability—Per Acre

Feed pool		Phalaris White Clover			Winter Grazing Oats		
		DOM (lb)	LSM*	Totals	DOM	LSM	Totals
Autumn A	M1	255·4	3·20				
	M2	189·6	2·37				
	A1	170·6	2·13	7·70			
Autumn B	A1	140·6	1·76				
	M1	67·5	·84				
	M2	77·7	·97	3·57	200	2·5	2·5
Winter A	J1	59·3	·74		250	3·12	
	J2	56·5	·70		250	3·12	
	J1	41·5	·59	2·03	200	2·5	8·74
Winter B	J2	46·7	·58		200	2·5	
	A1	91·6	1·15		300	3·75	
	A2	93·4	1·17	2·90	300	3·75	10·0
Spring A	S1	144·0	1·80		400	5·0	
	S2	199·8	2·49		400	5·0	
	O1	357·8	4·47	8·76	300	3·75	13·75
Spring B	O2	386·3	4·83		300	3·75	
	N1	371·8	4·65				
	N2	334·3	4·18	13·66			3·75
Summer A	D1	260·8	3·26				
	D2	220·5	2·76				
	J1	242·0	3·02	9·04			
Summer B	J2	223·9	2·80				
	F1	206·3	2·60				
	F1	228·0	2·85	8·25			
				55·91			38·74

FIGURE I

Yearly Feed Requirements for One Cross Bred Breeding Ewe (120 *lb*) *and Follower Over the Given Range of Lambing Times—LSM's*



6 LABOUR REQUIREMENTS

The labour requirements for the flock when lambing are difficult to define because there is great variation between graziers' estimates (and their practices). The estimate is based on an experienced man being able to handle 400 ewes lambing over four weeks, a requirement of 0·4 hours per ewe. Because it is not certain a ewe will lamb the actual requirement per ewe joined is:

July		August		September		October		November	
J1	J2	A1	A2	S1	S2	O1	O2	N1	N2
·0354	0·372	0·388	0·398	0·398	0·39	0·38	0·35	0·31	0·247

7 LAMB SALE

The time of sale of lambs and the price received are the basic variables in the model. The model was used for a number of different price combinations for the various possible sale dates.

TABLE 9

A Reduced Version of the Matrix to Illustrate Row and Activity Interactions

Row name		Ewe activities														Lamb sell		Feed					Labour		Row type	R.H.S.
		Supply					Breeding			Replace deaths						Sell culls	Pool		Buy		Transfer			July	Aug.		
		Buy	Transfer							Transfer			Buy														
			4TA-B	4TB-C	6TA-B	6TB-C	4TJ1	4TJ2	6TA1	4T	6T	FM	4T	6T	FM		1	2									
Objective		−1·5											−10	−8	−6	4	7·5	7·0	−·7	−·7				−1·5	−1·5		
4TEA		−1·0	1				1·0																			=	0
4TEB			−1	1			0·0	1·0																		=	0
4TEC				−1			−·137	0·0																		=	0
4TED								−·069																		=	0
6TEA		−1·0			1																					=	0
6TEB 6TEC					−1	1 −1			1·0																	= =	0 0
FMEA		−2·0																								=	0
Lamb Survival Pools	1								−·851								1									≤	0
	2						−·606	−·655										1								≤	0
Ewe Survival Pools	4T						−·750	−·809		1																=	0
	6T								−·873		1															=	0
	FM											1														=	0
Ewe Repl. Pools	4T						−·863	−·931		1			1													=	0
	6T								−·970		1			1												=	0
	FM											1			1											=	0
Cull	FM															2										=	0
Feed Supply	Aut. A						1·65	1·65	1·65												1					≤	2,310
	Aut. B						1·75	1·70	1·65												−·5	1				≤	1,121
	Wint. A						3·05	2·40	2·90										−1			−·5	1			≤	784
	Wint. B						2·87	3·31	3·34											−1			−·5			≤	1,070
Labour	July						·354	·372																−1		≤	160
	August								·388																−1	≤	160