FACTORS LIMITING THE VALUE OF AI AND MOET IN A THREE-TIERED SHEEP BREEDING SYSTEM

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SUMMARY

A computer model of a 3-tiered sheep breeding scheme indicates that at a discount rate of 5% the costs of AI and MOET could rise considerably before becoming uneconomic, and the number of lambs that can be born by these techniques are well above levels that could be economically limiting. Selection procedures of low accuracy and inefficient age structures would not preclude the use of AI and MOET. MOET and AI would be useful in populations down to 250,000 breeding ewes at the commercial level. Commercial returns do not occur for several years after the breeding costs are incurred, so the discount rate is very important. At rates over 10% the optimum system without MOET and AI uses less expensive selection methods (with lower accuracy) but has a structure that reduces the loss of additive genetic variance and reduces the genetic lag between the nucleus and commercial flocks. This results in overall efficiency similar to that obtained with the use of MOET.

INTRODUCTION

Previous studies have shown that MOET can give valuable genetic gains from increased use of the best ewes, using reasonable multiplier systems to provide rams for commercial wool sheep operations (Gaffney et al. 1991). It has also been shown that AI is useful in the multiplier flocks (Wade et al. 1991), but probably not in the commercial flocks (Morley 1991). A model of a three tiered sheep breeding system using AI and MOET described previously (Horton, 1993) allows the optimisation of a large number of variable options. This uses a genetic algorithm - a computing method, not a breeding system (Goldberg 1989) - where a range of options is allowed to vary simultaneously to find the optimum combination under specified conditions. An improved version of the model has been used here to determine which factors might make the use of AI and MOET uneconomic. This model allows the entire structure to be optimised according to the breeding methods available.

Table 1. Assumptions held constant during each run of the model

Total number of ewes in all tiers	1,000,000 ewes
Age at which commercial ewes and rams are culled	6 years
Weaning rate for ewes	70% maidens, 80% mature
Deaths per year	5% hoggets, 3% adults
% lamb cull not related to performance	30% ram lambs, 5% ewe lambs
Heritability of the production traits of interest.	0.4
Coefficient of variation of the production traits	10%
% production loss for each 1% increase in inbreeding	0.5%
Ewes/ram	40 natural, 2000 for AI
% ewes lambing after AI (backup rams used for remainder)	60%
Cost of AI	\$500/ram + \$25/ewe
Cost of MOET per lamb born	\$220
Number of lambs from each MOET ewe/year	8
Maximum number of lambs born/year in nucleus	2000
Discount rate for future gains	5%
Annual value of wool/adult ewe or hogget	\$15
Sale of ewe or wether hoggets	\$15
Sale of culls	\$6/cfa ewe, \$8/adult ram, \$8/hogget ram

Production is based on data supplied by Department advisers, values for AI and MOET from Evans (1991), and losses from inbreeding from Ercanbrack and Knight (1991).

Table 2. Breeding options varied by the model.

Breeding option		Possible Range	Number of choices
Ewes/ram	nucleus	10 - 320	32
No. of AI rams -	daughter flocks	0 - 60	16
No. of nucleus ewes used for MOET		0 - 248	32
Max. years used	nucleus rams	1.0 - 2.5	16
	daughter flock rams	1.0 - 4.2	16
	commercial flock rams	2.0 - 5.0	16
Surplus matings/ewe	nucleus	0.0 - 4.0	20
	daughter flock	0.0 - 3.1	32
No. of ewes in nucleus flock		100 - 3200	32
No. of ewes in daughter flocks		20000 - 82000	32
% of nucleus ewes from daughter flocks		0 - 90	16
% of daughter flock ewes from commercial flocks		0 - 35	8

A further 5 variables were used for selection methods for nucleus and multiplier flock rams and ewes, and for commercial ewes. These selection methods allow a range of cost and accuracy from no cost (and zero accuracy) up to \$20/sheep for 80% accuracy

Surplus matings/ewe indicates the number of times ewes are mated beyond the minimum required to provide replacements within that tier (after allowing for commitments to higher tiers).

METHODS

A computer model described previously (Horton 1993) was extended, primarily by the use of Hill's method (1974) to determine total future returns from the selection system, and by allowance for loss of additive genetic variance as described by Keller et al. (1990). The optimum is defined as the system providing the greatest percentage return on investment, as suggested by Ponzoni (1988). Table 1 shows the assumptions that were used as defaults in the standard model. The options that were allowed to vary, and their permitted range, are shown in Table 2.

RESULTS

Costs and numbers of lambs produced

At $220/lamb MOET can give useful benefits with only 2 lambs per ewe, but the cost of MOET could increase to $500/lamb if at least four lambs/ewe are produced each year (Table 3). The model usually prescribes MOET for only a portion of the nucleus group, but AI is normally chosen for either all ewes or none at all in the multiplier flock (Table 4). With large numbers of ewes (500 per ram) AI is useful at a cost as high as $60/lamb, but with only 300 ewes/ram the cost must be $20/lamb or less.

Table 3. Percentage of nucleus lambs born to MOET ewes in the optimum structure

Cost per MOET lamb	Lambs per MOET ewe/year 2	4	8
$220	92	97	98
$500	16	88	87
$1000	8	8	29

Table 4. Percentage of daughter flock ewes mated to AI rams in the optimum structure

AI Cost per Lamb	Ewes per AI ram 200	300	400	500	1000	2000
$20	100	100	100	100	100	100
$40	0	0	96	100	100	100
$60	0	0	0	100	100	100

Commercial flock size

When the nucleus is at least 500 ewes and the total number of ewes in the system is 250,000 or more, MOET is used in the nucleus and AI is used in the multiplier flock (Table 5), except in the case of a very large nucleus and small commercial flock where AI is not needed in the multiplier flock because the nucleus can supply nearly all the rams needed.

Table 5. Percentage of nucleus lambs born to MOET ewes (and use of AI in multiplier flocks*)

Ewes in Nucleus	Total number of ewes in the system 50,000	100,000	250,000	500,000	1,000,000
250	0	0	0	0	0
500	0	0	90*	90*	96*
1000	0	0	94*	85*	96*
2000	3	52	70	93*	98*

Selection methods and age structure

Both AI and MOET improve the low gains when selection procedures are limited to low accuracy (e.g. visual selection only by owner-classer). Using rams and ewes in the nucleus four times rather than only once is less efficient, but MOET and AI will still improve returns under these conditions.

Discount rate

Both MOET and AI were excluded from the optimum system when the discount rate was higher than 10%. At a discount rate of 10%, non-MOET/non-AI schemes were found that could give returns almost as good as the best MOET/AI schemes (Table 6). The structure differs from the MOET systems as follows - more ewes and rams in the higher tiers, but less expensive selection, except at the commercial level where promotion of ewes is allowed. This structure has much lower costs, a dramatic reduction in loss of additive genetic variance and a shorter genetic lag, so these factors compensate for reduced genetic gain.

Table 6. Return on investment (%) for the best MOET/AI and non-MOET/non-AI schemes

Discount rate	5%	8%	10%	12%	15%	20%
MOET/AI	153.6	125.1	116.5	110.8	106.7	103.6
non-MOET/non-AI	146.0	122.5	116.2	112.2	108.4	105.1

DISCUSSION

Most studies use discount rates in the range 5% to 10%. At a 5% discount rate the costs and number of lambs do not present restrictions to the use of MOET or AI if other aspects of breeding and selection are near optimal. However, although accurate selection and good age structures are valuable, they are not essential for benefits to occur from the use of MOET and AI.

At discount rates above 10% there are limited gains from MOET and AI. Returns from alternative investments (off-farm or on-farm) could be a major factor restricting the use of these relatively expensive methods. Other models have indicated that MOET is still useful at a discount rate of 10% or higher (Gaffney et al, 1991). However, these systems have not usually allowed for major variation of the multiplier unit when comparing the optimum MOET and optimum non-MOET structures.

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