Economic benefit of sheep AI

Two questions were addressed by the following article. The first section assessed genetic gain achievable by using AI, and then estimated the dollar value accrued over 5 to 10 years. The second section evaluated the benefit of increasing the number of progeny resulting from refinements of the AI protocol, presents benefit cost ratios associated with such changes, and assessed the economic benefit to the Australian sheep industry.

1. Increased rate of genetic gain with artificial insemination in sheep breeding programs

Introduction

Rate of genetic gain is a function of selection intensity (i), accuracy (r), generation interval (L) and genetic standard deviation (σ) for males (m) and females (f) (equation 1). Increasing use of artificial insemination in a nucleus flock (or herd) increases the selection intensity for males, i.e. selecting only the very best for the relevant breeding objective and selection index.

Equation 1 –response to selection

$$R = \frac{i_m r_m + i_f r_f}{L_m + L_f} \sigma_G$$

Approach

Two mating ratios were compared of 35 females per male (to reflect no or minimal use of AI) and 50 females per male (to reflect extensive use of AI), therefore reflecting a substantial difference in male selection intensity significantly between the scenarios. This was undertaken for a common Merino dual purpose index. The flock characteristics assumed are detailed below with the extensive performance recording detailed in Appendix 1.

- Weaning rate: 100% (i.e. 100 lambs weaned per 100 ewes joined)
- Earliest possible age of first drop males: 2 years
- Earliest possible age of first drop females: 2 years
- Adult mortality rate: 3%
- Maximum age: 10
- Optimised generation interval
- Percent emphasis on the selection index: 75% males and 50% females

Results and implications

In the scenario described the estimated increase in rate of genetic gain, when increasing selection intensity on males, increased the expected rate of genetic gains by \$0.21/year per ewe joined, from \$3.00/year to \$3.21/year, equivalent to approximately 7% above trend. The predicted rates of genetic gain are aligned with the very highest rates of genetic gain observed in Merino flocks in Australia on Sheep Genetics – Merinoselect. The predicted increase reduces to \$0.11/year per ewe joined if expected rate of gain is $2.50 (vs. $2.61/year) owing to reduced selection emphasis on the index. Moreover, if selection emphasis on the index declines further, the additional genetic gain diminishes towards zero, and additional recording or artificial breeding expenses present a cost without a return. The results are discussed below using the highest rates of genetic gain, i.e. $3.00/year vs. $3.21/year.

Genetic gain is permanent and cumulative. For +$0.21/year additional gain, when considered at a 7% discount rate, the additional total profit added across the value chain is expected to be $2.64/ewe joined after 5 years, $6.66/ewe joined after 10 years. These are the additional whole of value chain profit increase per ewe joined, in real terms at 7% discount rate. When multiplied across a large number of ewes the predicted value chain benefit is substantial. For example, a nucleus flock of 2000 ewes is likely sufficient to breed rams for mating of 100,000 commercial ewes per year. The additional 5-year value chain wide benefit is expected to be $264,000 whilst the additional cost of AI for 2,000 ewes is likely under $100,000 (assuming $50 additional cost per ewe artificially inseminated). As noted earlier, this is only achieved where flocks have high levels of estimated breeding value accuracy, achieved through thorough performance recording and/or genomic testing and place significant selection emphasis on the selection index.

2. Benefit cost analysis of refined AI protocols

Introduction

The AWI Ltd research project "Improving the success of sheep artificial insemination programs" (ON-00488) examined modified treatment protocols to improve synchrony of oestrus and pregnancy rates. The modified protocol deserving an economic assessment is the pre-treatment with PGF2α 27 days before pessary insertion. This protocol results in an additional 35 fetuses for each 100 ewes inseminated. The economic assessment involved:

a) Determination of extra revenue produced by the additional progeny.
b) Evaluation of additional costs made to generate the extra progeny.
c) Calculation of benefit cost ratios.

Extra revenue from progeny

The value of the additional lambs at hogget age was estimated at $688 per head. This figure was provided by members of the South Australian Stud Merino Breeders Association who considered it a conservative estimate. The following assumptions were made:

- *Ewe progeny*
    - One third of ewe lambs are culled as hoggets and valued at $250 each.
    - Two thirds of the ewe lambs enter the stud flock as hoggets and are valued at $350 each.
    - The feed cost of ewe progeny was estimated at $50 per head per year which is equivalent to the value of wool harvested at lamb and hogget shearing.
    - The average net value of ewes, as derived from the values above, is $317 each.

- *Ram progeny*

- One third of ram lambs are culled for slaughter at hogget age and are valued at $180 each.
- One third of the rams are sold at hogget age and are valued at $1000 each.
- One third of rams are sold as hoggets at an average of $2000 each (most studs at property auction are selling rams at an average of $2000 - $3000).
- The cost of feeding rams before sale is estimated at $100 each, equivalent to the funds received for sale of wool harvested as lambs and as hoggets.
- The average net value per ram, as estimated from the values above, is $1060

- *Ewes and rams*

The average net value of combined progeny at hogget age, assuming a sex ratio of 1:1, is $688.

Additional costs

Additional costs of the new protocol per inseminated ewe are $2 for PGF2α treatment and $2 per ewe for extra handling and mustering associated with this treatment. These additional costs equates to $4 per inseminated ewe.

Benefit cost ratio

The benefit cost ratios, based on progeny value at hogget age of $688, additional cost of $400 per 100 ewes inseminated and a survival rate to hogget age of 85% are presented below.

Extra lambs at hogget age	Benefit cost ratio
1	1.72
10	17.20
20	34.40
30	**51.60**

Estimated value to the stud breeding industry

If it is assumed that approximately 175,000 Merino ewes are inseminated in Australia annually, that a further 50,000 ewes from other breeds are inseminated (information from Sheep Breeding Technology / Australian Wool Innovation) and that 30 extra hoggets are generated per 100 ewes inseminated, then the net value of the new protocol to the national sheep industry is approximately $36.1m annually. This does not include potential economic benefit due to genetic gain, as outlined in the first part of this document.

However, two factors will impede the rate of adoption of the new protocol.

- Its use is dependent on ewes cycling naturally at the time of PGF2α treatment. This limits its use in Spring when approximately 50% of ewes can be expected to be in anoestrus. Research to be conducted in Spring, 2021 is expected to overcome this problem but this cannot be guaranteed. Failure to adapt this protocol for use in Spring will result in a 50% reduction in the national benefit (assuming that approximately equal numbers of ewes are inseminated in Spring and Autumn).

- Reticence of practitioners to use the new protocol. Whilst this is expected to be a transient problem, it has the potential to limit the economic value that would otherwise be realised.

Appendix 1

TRAIT RECORDING	Abbreviation	Measurement Males	Measurement Females	Measurement in time units	Measured in Ref Pop (1 = yes)
Genotyping	DNA	1	0		
Birth					
Birth weight	bwt	1	1	0	1
Weaning weight	wwt	1	1	0.4	1
Weaning worm egg count	wfec	0	0		0
PostWeaning					
Post weaning weight	pwt	0	0	0.5	1
Post weaning eye muscle depth (C)	pemd	0	0	0.5	1
Post weaning fat depth (C)	pfat	0	0	0.5	1
Post weaning WEC	pfec	0	0	0.5	1
Yearling					
Yearling weight	ywt	1	1	1	1
Yearling eye muscle depth (C)	yemd	0	0	1	1
Yearling fat depth (C)	yfat	0	0	1	1
Yearling worm egg count	yfec	0	0	1	1
Yearling greasy fleece weight	ygfw	0	0	1	1
Yearling clean fleece weight	ycfw	1	1	1	1
Yearling mean fibre diameter	yfd	1	1	1	1
Yearling CV fibre diameter	ydcv	1	1	1	1
Yearling curvature	ycuv	0	0	1	0
Yearling scrotal circumference	ysc	0	0	1	0
Yearling staple length	ysl	0	0	1	1
Yearling staple strength	yss	1	0	1	1
Post weaning scrotal circumference	psc	0	0	1	0
Muscle conformation (mm)	conf	0	0		1
Dressing percent	dress	0	0		1
Saleable meat yield percent	smy	0	0		1
Adult					
Adult body weight	awt	0	0	2	1
Adult greasy fleece weight	agfw	0	1	2	1
Adult clean fleece weight	acfw	0	0	2	1
Adult mean fibre diameter	afd	0	1	2	1
Adult CV fibre diameter	adcv	0	1	2	1
Adult staple length	asl	0	0	2	0
Adult staple strength	ass	0	0	2	0
Adult curvature	acuv	0	0	2	0
Number of lambs born	nlb	0	0	2	0
Number of lambs weaned	nlw	0	0	2	1

Prepared by SARDI Reproduction Research Team with assistance from the South Australian Stud Merino Breeders Association. Dr Stephen Lee, University of Adelaide, prepared the section on genetic gain. Software developed by Prof Julius van der Werf was used for this modelling.