Proc. Assoc. Advmt. Anim. Breed. Genet: 26: 291-294

COST-BENEFIT OF GENOTYPING COMMERCIAL MERINO SHEEP

G. Rose[1], S. Martin[2], D.J. Brown[1], L.P. Kahn[3] and J.H.J. van der Werf[3]

[1] Animal Genetics Breeding Unit*, University of New England, Armidale, NSW, 2351 Australia
[2] SheepMetrix, Young, NSW 2594 Australia
[3] School of Environmental & Rural Science, University of New England, Armidale, NSW 2351 Australia

SUMMARY

Genomic predictions of genetic merit are commonly used in the seedstock industry but application to commercial livestock systems is lagging in comparison. Therefore, this paper aims to show the cost-benefit of using genomic information in culling and selection decisions of commercial Merino sheep. The benefit of such information depends on the achieved selection superiority and the number of discounted expressions of that superiority in the future. We compared a moderately accurate genomic test with average accuracy of 57% across all traits with a highly accurate test with average accuracy of 80% across all traits. The break-even cost of genotyping males in a multiplier flock for use as sires in a commercial flock was AU$258 (moderate accuracy) and AU$377(high accuracy) and for ewes in the multiplier flock it was AU$107 (moderate accuracy) and AU$156 (higher accuracy). The break-even cost of selecting replacement ewes in a commercial flock is between AU$14 and AU$21. These results indicate that there is opportunity for cost-effective genotyping in commercial Merino flocks, especially where home-bred rams are selected from a multiplier flock.

INTRODUCTION

Genomic testing has rapidly been adopted in the seedstock industry, with over 0.5 million animals genotyped in the Sheep Genetics database (MLA 2024). Genomic prediction is becoming more accurate as more animals with measured phenotypes also have genotypes. While most of the genomic testing completed is currently in seedstock breeder flocks, there is potential to extract value from genomic testing in commercial flocks. Genomic predictions have already been used to predict genetic merit of animals at a flock level, such as the current Flock Profile prediction (Swan *et al*. 2018) for commercial Merino flocks. Commercial producers use a Flock Profile to help benchmark where their flock sits within industry and use the results to choose better genetic merit rams and track genetic progress. Individual prediction of the genetic merit of commercial sheep without recorded phenotypic information could also be useful to rank animals within flock, e.g. for decisions around culling or mating of ewes for flock replacement, or for selecting ewes or rams in multiplier flocks to improve the genetic merit of sires used in commercial flocks. Genotyping of commercial cattle is already utilised in the beef and dairy industries, but the value proportion has not been explored in sheep. Therefore, the aim of this paper was to develop a cost-benefit analysis of genomic prediction in commercial Merino's to underpin potential adoption of the technology in the sheep industry.

MATERIALS AND METHODS

The value of using genomic prediction in decision making was modelled for a commercial Merino sheep flock. This modelling estimated the cost-benefit and break-even costs of genotyping to get a genomic breeding value (GBV). Commercial GBV products are not yet available in sheep,

*A joint venture of NSW Department of Primary Industries and Regional Development and the University of New England so we compared tests with assumptions about accuracies to show the value of potential future products. We used selection index theory to predict selection differentials of selected ewes or rams using the Sustainable Merino (SM) index (MLA 2024) as an objective. Selection accuracy was compared for three different information sources:

1. A postweaning phenotype for weight, fibre diameter and clean fleece weight;
2. A moderately accurate genomic test, similar to the current expected accuracy (equivalent to having five progeny measured, average accuracy across 20 traits = 57%); and
3. A more accurate genomic test, as to be expected in the next few years (equivalent to 20 progeny measured, average accuracy across all traits = 80%)

Other traits included weight (4 traits), fibre diameter (3) and clean fleece weight (3) at different age stages, staple strength (3), condition score, faecal egg count, number lambs weaned, lean meat yield, intramuscular fat, dag and breech wrinkle scores. We predicted future expression of selection superiority of ewes or rams in their descendants, or of their own phenotype using a deterministic geneflow method. The benefit of selective culling depended on:

1. The predicted difference, how much better are the animals that are kept?
2. The number of future expressions of that superiority, which in turn depends on:
    a. The number of future phenotypic expressions of the animals itself
    b. The number of expressions in future offspring and their descendants
    c. When these expressions are realised, as future benefits should be discounted

Future expression of the selection superiority of selected parents was modelled with the gene flow method (Hill 1974). Three scenarios of selection were considered: 1) selection of replacement ewes in a commercial flock, 2) selection of males born in a multiplier flock, to be used as sires in a commercial flock, and 3) selection of ewes within the multiplier flock.

Selection index theory was used to predict selection superiorities, from the regression of the breeding objective on the information that is used to predict it. These predictions were calculated using MERINOSELECT genetic parameters for 20 traits (not all trait results presented) and economic values (pers com Sheep Genetics).

Table 1 shows the proportion of selection superiority in 1-year old offspring of commercial rams and ewes resulting from selection of: 1) commercial flock replacement ewes, 2) multiplier males to be used in the commercial tier, and 3) multiplier replacement dams. Considering a time horizon of 20 years, the cumulative discounted expression (CDE) is the sum of these expressions after discounting them at 5% based on year of expression. When calculated over a 20-year time horizon and per breeding ewe in the flock the CDE for these three scenarios is 0.676, 0.721 and 0.446, respectively.

Table 1- Proportion of selection superiority in 1-year old offspring of commercial ewes resulting from selection of 1) commercial replacement ewes, 2) multiplier males to be used in the commercial tier, and 3) multiplier replacement dams

Selection strategy	Year after selection									
	1	2	3	4	5	6	7	8	9	10
Replacem. Ewes Comm.	0.00	0.11	0.10	0.10	0.10	0.10	0.10	0.04	0.05	0.04
Multiplier Males	0.00	0.18	0.17	0.17	0.04	0.05	0.05	0.05	0.05	0.04
Multiplier Dams	0.00	0.00	0.00	0.02	0.04	0.05	0.05	0.06	0.06	0.06

Value of selecting better replacement females in a commercial flock. We assumed a flock of 1,000, breeding ewes with a weaning rate of 1.2 lambs per breeding ewe, an annual attrition rate of

10%, and a culling age of 7 years for the ewes. This resulted in a replacement rate of 23.7% of hogget ewes entering the breeding flock. Hence 237 ewes were selected at hogget age from 432 candidates (selection rate of 54%), if only 80% of 540 hoggets was genotyped or measured for phenotype.

Economic values accounted for multiple expressions and discounts for traits expressed later in older animals. Therefore, we calculated the value of selection based on the genetic value of ewes expressed at 2 years old. The value of selecting better replacement ewes is then equal to i.(S_p *CDE_p + S_gCDE_g).EconVal per replacement ewe, where i = 0.72 is the selection intensity, S_p and S_g are vectors with the phenotypic and genetic selection differential for each trait, respectively, CDE_p and CDE_g are the phenotypic and genetic cumulative discounted future expressions of traits in the entire commercial flock (0.81 × 1,000 and 0.676 × 1,000, respectively), and EconVal is a vector with the economic value for each trait.

Value of selecting better multiplier rams and dams. We assumed a commercial flock of 8,000 ewes with rams sourced from a multiplier flock of 400 breeding females. Rams for the commercial flocks were kept for 3 matings. Annually, 59 rams were selected from 173 candidates (34%) and 95 ewes from 173 candidates (55%) that were measured or genotyped in the multiplier flock. The CDE in the commercial flock of 8,000 ewes is calculated as 0.721 × 8,000 = 5771. Selecting replacement ewes for the multiplier flock results in CDE in the commercial flock of 8,000 ewes of 0.446 × 8,000 = 3,568. The cost benefit analysis estimated the break-even cost of testing. The break-even cost was the profit per selected animal multiplied by the number of selected animals and divided by the number of animals that were DNA-tested.

RESULTS AND DISCUSSION

Table 2 shows the benefit of selection, expressed in dollar value per selected ewe. The example in Table 2 had 213 selected ewes expressing the benefit while there were 432 ewes genotyped. The results show that the break-even cost for obtaining information is modest, ranging between AU$7 and AU$22, which is lower than the current genotyping cost. It should be stated that the difference between phenotypic selection and genomic selection is the largest selection differential and benefit that can be obtained with genomic selection. There is also a shift towards more benefit for hard to measure traits, such as reproduction and other traits related to sustainability. For example, with selection on phenotype, 65% of the benefit is due to improvement of wool traits and 35% is from reproduction traits indirectly through selection on live weight, whereas with accurate genomic selection these relative contributions are 27% and 73%, respectively.

Table 2. Benefit per selected replacement ewe of three selection strategies for replacement females in a commercial flock, and the break-even cost of collecting the information used for selection, using 20 traits

Selection criteria	Benefit per selected ewe	Break-even cost
Selection on phenotype	AU$14.19	AU$7.01
Selection on genotype (~57% accurate)	AU$ 28.66	AU$14.16
Selection on genotype (~80%accurate)	AU$43.69	AU$21.58

The break-even cost is quite insensitive to several assumed parameters, in particular weaning rate and replacement rate. A weaning rate of 1.5 would give a break-even cost of genotyping of AU$14.10, rather than AU$14.16 as in Table 2 (weaning rate 1.2) as the extra benefits per ewe are offset by more genotyping per selection candidate, i.e. there are more selection candidates, and this outweighs the greater selection intensity. The proportion of selection candidates that is genotyped may vary, with a lower proportion genotyped giving lower costs but also lower selection intensity.

Genotyping a larger proportion is more beneficial with similar break even cost for any genotyped proportion of ewes >75%. Table 2 shows clearly that the accuracy of the genomic test has a large effect on the break-even cost of genotyping.

Table 3 shows the break-even cost for selecting males or replacement females in the multiplier flock, respectively. The break-even cost is a lot higher for the multiplier because the much larger number of animals that benefit compared to the number of animals genotyped. Furthermore, the selection intensity in the rams selected in the multiplier flock for use in the commercial flock is higher, which also leads to a different optimal proportion of males genotyped. This optimal proportion of multiplier males genotyped was around 50-60%, with a break even cost of AU$270 whereas the break-even cost with 34% genotyped was AU$257. Selecting of males in the multiplier has a higher break-even cost compared to selecting females because fewer males were selected from potential candidates (34% in males compared to 55% in females).

Table 3. Benefit of three selection strategies for selecting rams and ewes from the multiplier and the break-even cost of collecting the information used for selection

Selection criteria	Selection in rams	Selection in ewes
Selection on phenotype	AU$ 141.46	AU$ 58.78
Selection on genotype (~57% accurate)	AU$ 257.73	AU$ 107.09
Selection on genotype (~80% accurate)	AU$ 376.61	AU$ 156.49

CONCLUSIONS

These results indicate that there is opportunity for cost-effective genotyping in commercial Merino flocks. This opportunity seems to be attractive at this stage to commercial producers that use a multiplier flock to breed rams for their commercial flocks based on the current cost of genotyping. These benefits do not include other potential advantages of having genotyped animals, for example, being able to inform potential buyers of commercial ewes the genetic potential of animals. Despite this, this research shows the potential benefits that commercial genotyping products have for the Merino sheep industry in Australia.

ACKNOWLEDGMENTS

Funding for this work was from MLA-MDC project P.PSH.1483 and through funding from the Australian Government's Future Drought Fund.

REFERENCES

Hill W.G. (1974) *Anim. Sci.* **18**: 117.

Meat and Livestock Australia (2024) MERINOSELECT indexes A ram breeder's guide. https://www.sheepgenetics.org.au/globalassets/sheep-genetics/getting-started/sheep-genetics---asbvs-and-indexes/merinoselect-indexes-breeder-2024.pdf

Swan A.A., Gurman P.M., Boerner V., Brown D.J., Clarke S., Gore K., Granleese T. and van der Werf J.H.J. (2018) *Proc. World Cong. Genet. Appl. Livest. Prod.* **11**: 346.