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Optimising Current Generation Gains to Supplement Genetic Gain in Commercial Sheep Flocks

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ABSTRACT: There have been many advances for the sheep industry in the last two decades with large improvements in technology for more efficient and reliable data collection and measurement and more information and analysis available for better informed ram selection decisions. With much focus on increasing genetic gain, ease of management and reduction in cost there has been much less focus on ewe selection within flocks for lifetime performance. This paper discusses the opportunities (using simulation and prediction models with optimising capabilities) to make better use of information already available to producers, which not only enables higher economic benefit for current production from animals but also complements genetic gains for future generations, at little or no extra cost. Selecting the best ram is high priority but also of importance is making better use of current and historical measurements of ewes in commercial sheep flocks.
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Introduction

Traditionally, the rate of change in the sheep industry has been much slower than in other agricultural industries. ABARE (2002) showed that cattle and cropping increased at a rate of 2.1% and 3.6% respectively from 1982 to 2002, whilst the sheep industry only increased at a rate of 0.6%. Cropping has a history of continual adaptation to ensure it remains competitive with the rest of the world and they rely on many improvements in technology as well as management strategies to ensure optimal production. The sheep industry seemed to lack this drive for rapid improvement from competition and price fluctuations. When profit margins became tighter in the sheep industry more emphasis was placed on the need for change and producers and researchers were looking for ways to increase production, lower costs, lower labour and ultimately increase profits.

Atkins et al. (2006) noted that the majority of gains in the past were made from labour productivity, land use and a less dramatic increase in animal productivity, and that these past gains were no longer adequate. Large improvements have been made in technology for ways of capturing and recording measurements in an efficient manner and less labour intensive to make it become feasible for larger commercial flocks The advantages of collecting various measurements and using genetic information in commercial sheep flocks have been largely unidentified and underutilised. Traditionally, most genetic progress in commercial flocks has been derived from ram selection (Atkins et al. 2006) and few measurements have been made on ewes. Flocks were managed with limited data collection (to reduce costs) and animals were managed as a single entity (flock level management with animals managed as single homogenous groups).

As our understanding of genetics and flock structure and management improves, our breeding schemes reflect these changes. Arendonk et al. (1998) noted that breeding schemes in the late nineties were very different in structure and size than those that were in place decades earlier, and this is still true for today. Arendonk et al. (2006) understands that many of these changes have been in response to better adaptation of technologies, but also recognises that there is a large scope for improvement by making better use of the currently available technologies, which is one of the main issues this paper aims to highlight. There have been many more advances in technology since this comment was made in his paper, and yet not much improvement in using them any more efficiently.

Current generation improvement

There is a large amount of variation in traits that can be exploited within each flock for fast current generation improvement (Atkins et al. 2006), which will then flow through future generations. This range of variability within a flock questions the traditional management of treating the whole flock as one. Currently most maiden ewes are selected to enter the breeding flock via visual classing methods and once selected, remain in this group until the whole group exits at a certain age. Throughout their lifetime these animals are treated as a single group and are run with an aim of maintaining them at minimal cost. Rowe and Atkins (2006) suggest this may not be best practice and provide an alternative view of using precision sheep management to increase productivity and profitability in the Australian sheep industry. They believe it is important to identify the animals which contribute the most to profitability as well as those that are costing the system the most.

Decision support tools have been used to predict the impact of current decisions on potential future decisions and the future production for whole flock changes over time (Kelly et al. 2006). They have highlighted the benefits of optimising flock structure to ensure optimal genetic progress as well as identifying selection options to achieve desired breeding objectives (Atkins et al. 2006). Ewe selection is often perceived to be of little benefit due to the low genetic gain it achieves. However, current generation gains from selection can be quite large (and profitable), with genetic progress an added advantage.

The financial benefit of these opportunities has previously been hard to quantify and the value has often been undervalued and overlooked. More recently studies in the area of precision sheep management have shown that there are large opportunities for current generation gains and most of this work has focused on selecting animals from an early age and the impact on the combined current and future gains for overall flock performance. There is potential for further opportunities of reusing this information later in life to make more selection decisions with little or no extra measurements required, such as culling on performance rather than age, resulting in even more production (or economic gain) of the flock.

Reproduction example

Increasing flock reproduction is a good example of where this concept can be applied. Reproduction is lowly heritable and low-moderately repeatable. Therefore, most benefit of selection is made in current lifetime performance. By identifying the better performers (ie those that produced more lambs) early, the poor performers (or dry ewes) can be removed from the system early. This is reducing costs of keeping ewes that don't contribute to the reproductive performance of the flock and increases the resources available for the more productive ewes. Many producers use this knowledge by culling ewes that are dry once (or sometimes dry twice) to make the most of this advantage at a young age. Research has shown this to be a good approach as Lee and Atkins (1996) found that ewes that produced lambs in their first two joinings subsequently reared twice as many as those that didn't rear any lambs in their first two joinings and would therefore be keeping more reproductive ewes.

There is potential to gain further benefit from this information though, with recording lifetime records of those ewes rather than basing it on a single decision when a ewe is dry early in life. Lifetime records are now much easier to collect using tools such as Pedigree MatchMaker (Richards & Atkins 2007) requiring little labour. By recording lifetime reproductive performance of the ewes the decision to keep a ewe longer or cull her earlier can be made later in life rather than the more common approach of culling on age irrespective of reproductive performance and potential. Many factors impact the decision of when it's best to cull a ewe. Such factors include

- possible decrease in reproductive performance after a certain age
- impact on selection intensity (with keeping older ewes longer there are less maidens entering the flock)
- probability of survival decreasing with age
- balance of proven performance of older ewes and potentially better genetic merit of younger animals, and
- number and age of the surplus animals for sale.

In order to help predict the impact of all of these issues, and the impact on production and economic values, simulation of flocks and predicting future performance is a useful technique.

Lee et al (2006) have shown through flock data from three sites that there is certainly potential for keeping higher performing ewes for longer as a way of increasing net reproduction rate. Their paper showed a difference of 3 to 6 times between the top and bottom quartile of three flocks in net reproduction rates. By using this information they suggest that removing poor performers earlier and keeping the higher performers longer, the achievable flock reproduction rates by Merino ewes could be much higher than current expectations based on whole flock means. This trial shows there is benefit in collecting and using this type of information, but identifying which is the most optimal tactic of selecting these ewes (ie how many in each age group or which ewes to keep or cull across age groups) is much more difficult.

Simulation, prediction and optimisation

Simulation allows a range of scenarios (flocks and environments) to be developed and future trait prediction enables a range of options to be examined without the large resources required for many field trials over time. Another very beneficial value of using models to identify the opportunities is that genetic algorithms can be used for finding the optimal solution. Rather than using trial and error to find ways of improving flock production or increasing financial gain, the selection of the flock can be valued in terms of fitness and the optimal solution can be found. This means that the value of the improvements need to be related to economic value (as a measure of fitness) and then the objective can be based on the scenario resulting in the highest fitness. In this example used, each lamb had a value per head and the objective for the flock was to find the best selection strategy that would produce the highest reproduction for that flock, ie the highest economic return (or highest fitness) was obtained with the highest number of lambs produced.

This optimal strategy can be found by using an evolutionary algorithm such as differential evolution (Storn & Price 1997). This method selects solutions that perform well and uses them to make a new generation of solutions, with iteration over generations to convergence.at the highest average flock reproduction (the desired objective in this case). The other benefit of using this simulation and prediction approach is that the best solution can be found for a range of different flocks with varying risks, environmental conditions and genetic potential that can be factored into the model. Additionally, sensitivity analyses can be undertaken to see what impact changes in underlying conditions have on the optimal solution, leading to identifying which solution gives the best overall outcome with accommodation of risk. This technique is valuable because general advice on the best approach for all flocks is not really applicable with all the considerations that should be made for each flock in different conditions.

This concept is obviously not just suited for reproduction and can be extended to other traits as well. The model just needs to be adjusted for impact of age on the trait measured (such as the broadening of the micron of a flock with increasing age) and correlations between traits used for the impact on other traits. The value of the whole process is increased when both reproduction and production traits are included, aiming for example to maximize total carcass value from the whole flock. This is because it is under these circumstances that the best solution is least obvious. By modifying the value of outcomes and the resulting fitness a range of objectives can be examined using this approach.

Conclusion

With the strong focus on genetic gain and advancement in various measurement and data capture technology it is important not to overlook the value of using this same information for current generation gain. The current generation can provide immediate financial gain and can complement the genetic gains for future production without requiring much extra measurement or management in many instances. Flock simulation, lifetime trait predictions and algorithms for optimising current measurement and selection decisions provide a very useful technique for identifying the best opportunities for increasing economic value that can be implemented for each individual flock (in various scenarios). Current generation gains are more than just a keep or cull decision early in life. Using these measurements later in life allows animals to be kept on performance (rather than dictated by age) and can provide financial advantage with little extra cost to the system. The benefits have been shown, and a method to find the optimal strategy has been identified with implementation now starting. There are large opportunities for gains in lifetime production and economic value when combining current information for lifetime improvement with resources for improved genetic contribution in later generations. There is room for rapid change with lots of improvements in technology, but this information and technology needs to be utilised better. Using methods such as this optimizing process is very important for advancing our ability to identify opportunities for better decisions and ultimately increased production and profit within commercial flocks. This approach is useful for any trait or species if the correct correlations and adjustments for age are used within the model and an appropriate objective set.

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