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Optimal development of Australian sheep genetic resources

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Abstract

The Australian sheep industry is currently facing changing market conditions in which the main driver of profitability is shifting from wool to meat production. Breeding objectives should respond to such market developments. Because current breeding objectives and indexes were developed separately for terminal sire breeds, maternal breeds and Merinos, price changes are accommodated by changing the weighting of traits. This article considers the development of breed types in relation to each other, taking into account the joint use of these breeds in a crossbreeding system. This article also addresses key issues about development of specialized vs. dual-purpose breeds and how the Merino breed should be developed optimally to maximize future profitability across the Australian sheep industry. A relatively simple model suggested that for a wide range of price ratios between wool and meat, a crossbreeding system with specialized breeds is more profitable than a system based on one dual-purpose breed. Optimal development involves increased growth for meat breeds but increased wool production and no increase in body size for wool breeds that also serve as dams of prime lambs. Reproductive rates of both wool and meat breeds should be increased.

Introduction

The survival of the Australian sheep industry depends on its ability to remain competitive in wool and meat markets. The competitiveness of wool has declined rapidly in past decades because of the emergence of cotton and synthetic fibres. Conversely, the decrease in the market share for sheep meat has stopped and sheep-meat exports have increased greatly in the past decade.

Wool and meat production have developed separately in terms of production units and production regions, but the Merino breed serves as a maternal resource for lamb production. Lamb production originally developed as a byproduct of Merino flocks. However, the proportion of Merinos declined from 95% to 85% of the national flock over the past decade and the proportion of terminal sire matings to Merino ewes increased from 15% to 45% between 1990 and 2002. Important issues in relation to these trends concern the future proportion of Merinos in flocks, the future roles of Merinos and other sheep breeds in wool and meat production, and the extent to which wool and meat can be combined in one production and breeding system. Important issues regarding breed development are to what extent the lambing rates and meat production abilities of Merinos should be increased if this occurs at the expense of wool production and whether a cross-breeding system with specialized wool and meat breeds is more competitive than a breeding system geared towards producing dual-purpose animals.

The aim of this article is to examine the development of breeding objectives across breeds under varying market scenarios. Joint development of breeding objectives for wool and meat breeds would need to account for their combined usage in crossbreeding and the potential for development in relation to each other. A relatively simple model was used to identify the major factors involved.

Wool Meets Meat (eds. P.B. Cronjé & D. Maxwell).
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Materials and methods

One wool breed and one meat breed, which broadly represents current sheep genetic resources in Australia, were considered. Three groups of traits were considered to be the main profit drivers: wool production, meat production and reproduction. For each of these trait groups, a composite trait based on the various traits currently included in industry selection indexes was constructed. The wool trait was based on an 18% micron premium ram power index, which included fleece weight, fibre diameter, staple strength, coefficient of variation of fibre diameter and mature body weight. The meat trait was based on a carcass-plus index, which included liveweight, fat and muscle at post weaning age. Table 1 shows the standard deviation of breeding value for each of these composite traits in monetary terms, indicating the amount of variation in profit in relation to each trait group. The estimated breeding value is equal to an index, with the standard deviation reflecting the variation in profit after accounting for differences in accuracy, e.g., because of low heritabilities. The correlation matrix shows that there are no unfavourable correlations between trait groups. The strongest correlations are between reproduction and meat; this would be an unfavourable correlation if the objective were to breed for higher reproduction and smaller-framed sheep.

Table 1. Standard deviation of estimated breeding value, true breeding value and correlations between wool, meat and reproduction as composite traits.

	Standard deviation of estimated breeding value[1]	Standard deviation of breeding value [1]	Accuracy	Correlations[2]		
				Wool	Meat	[3]Repro.
Wool	2.56	3.42	0.56	1.00	–0.09	0.14
Meat	2.58	3.73	0.48	–0.03	1.00	0.51
[3]Repro.	0.53	1.27	0.17	0.05	0.28	1.00

[1] Dollars per ewe; [2] Correlations between indexes are above the diagonal; correlations between breeding values are below the diagonal; [3]Reproduction.

Variances of and correlations between composite traits were based on economic and genetic parameters of their underlying traits (Table 1). Note that relationships between composite traits can differ from correlations between aggregate true breeding values as composite traits are mostly influenced by component traits that can be easily measured. Response to selection for each composite trait was predicted on the basis of selection index theory. For a given set of weights applied to composite traits, the response for each breed was predicted for a 20-year period. Optimal responses were derived using an evolutionary algorithm resulting in optimum development for wool and meat breeds when profit is the criterion of survival. The optimum breeding system (either crossbred or purebred) was based on composite trait means for each breed. Because of the linearity of the profit function used, only one system (either purebreds alone or a crossbred system) was optimal for a given set of parameters and prices. Maintenance of purebreds was accounted for when evaluating the profit of a crossbreeding system.

Results

In a situation based on current means (Table 2), the optimum system was a meat breed × wool breed crossbreeding system with purebred replacement crossings as well as crossbreds. These comparisons assume a price ratio for wool to meat of 12:1.2 (approximating the current price ratio of $12/kg for wool and $1.20/ kg liveweight for meat). Table 3 shows that although the purebred meat breed may be more profitable on a per head basis, the meat × wool crossbred system was more profitable on a dry sheep equivalent (DSE) basis because of lower maternal maintenance requirements.

Table 2. Relative output and efficiency of different genotypes under base parameters.

	Pure wool breed	Meat × wool crossbred	Purebred meat breed
Wool income	1.00	1.00	0.67
Meat income	1.00	1.13	1.67
Profit/head	1.00	1.06	1.11
Profit/DSE	1.00	1.06	0.97
Whole system profit	1.00	1.03	0.97

Initial profits and profits after 20 years of genetic improvement are given in Table 3 for three different price scenarios. With the current price ratio ($12/kg wool and $1.20/kg meat), the optimum selection strategy is to develop wool and meat breeds divergently, but to select both breeds for improved reproductive rates. The model indicated that when the price of wool decreases relative to that of meat, the selection emphasis on reproduction rate should be increased. When the price ratio was decreased by 50%, it was more profitable to farm with one meat breed. It should be noted that the decrease of body weight in the wool breed impairs genetic improvement for reproduction.

Table 3. Optimal development of wool and meat breeds under different price scenarios. Trait means are relative values: wool relative to wool breed mean and meat relative to meat breed mean in the current year; reproduction = number of lambs weaned per ewe; M × W, meat breed sires × wool breed dams; M x M, pure meat breed

Wool/meat price ratio	Wool breed trait means			Meat breed trait means			Optimum system	Relative profit	% wool
	Wool	Meat	[1]Repro.	Wool	Meat	[1]Repro.			
				Current Means					
12/1.2	100	80	0.90	67	100	1.20	M x W	1.00	54
				Means after 20 years of selection					
12/1.2	120	60	1.04	65	145	1.46	M x W	1.37	55
10/1.2	118	67	1.11	65	114	1.49	M x W	1.25	50
8/1.5				73	130	1.65	M x M	1.40	14

[1]Reproduction.

Discussion

Development of an appropriate breeding objective is critical to any genetic improvement program. Considering the increasing profitability of sheep meat, the direction of future development is critical for the Merino industry. There is a tendency to select for meat-related traits, which is likely to increase body weight. The model used in this study indicates that an optimal system is one in which crossbreeding is used, the dams of lambs produce wool, and ewes and maintain a relatively low body weight. This model did not account for decreased survival at lower body weights. Considering aspects of profitability such as resilience against droughts, we suggest that a decrease in body weight should be avoided. Furthermore, it would be possible to distinguish between growth, mature size and muscling within meat enterprises, which may reveal that the suitability of Merinos for lamb production can be improved without affecting maternal efficiency. Although more work is needed to optimize selection for underlying traits, these results emphasize the importance of maternal efficiency and the benefit of a small maternal breed for lamb production.

More detailed modelling of traits is required as well as a wider consideration of resources (e.g., different types of Merino) and heterogeneity of markets. Furthermore, genetic parameters were not varied in this study and correlations between the three trait groups are likely to be important for optimum development of breeds. Sensitivity analysis would also reveal the importance of accurate genetic parameters between trait groups, as discussed by Fogarty et al. (2006).

Genetic improvement of sheep has great potential. The meat-sheep sector has exhibited substantial genetic change during the past decade and this has translated into improved market share and profitability. The industry has adopted objective measurement and selection based on estimated breeding values. Successful young-sire programs are key drivers of genetic change (Banks et al., 2002). The Merino industry has made less progress than the meat-sheep industry. However, in past years there has been a large increase in the number of subscribers to formal genetic evaluation systems. For example, Merino Genetic Services has more than doubled the number of animals in their database over the past two years and now has data for 500,000 animals. The Sheep Genetics Australia database will contain data from more than 800,000 Merinos (A. Ball, pers. comm.). Thus, genetic evaluation technology is not only well developed in Australia but adoption is increasing across the sheep industry.

Market uncertainty may make it difficult to determine the most appropriate breeding objectives. Generally, multiple trait selection is sensitive to economic values when traits have unfavourable correlations. For example, with high micron premiums, selection for decreased fibre diameter is favoured, whereas with low premiums, the emphasis should be on fleece weight. Where sensitivity of breeding objectives to price ratio is high, risk is also high; strategies to deal with risk are part of optimal breeding programs. Development of two divergent lines could be considered as a risk-avoidance strategy because a cross of two divergent lines will be close to the merit of a line (breed) that would have been selected in an intermediate direction.

Based on current parameters, the genetic correlation between wool and meat indexes is close to zero (Table 1) and correlations may not be unfavourable. Although there is limited knowledge about possible trade-offs between meat and wool production, initial CRC research has shown that they do exist (Adams et al., 2005). The reason for separating wool and meat breeds is that wool and meat traits are expressed at different levels by ewes and their progeny. Current crossbreeding systems are relatively insensitive to economic factors. A dual-purpose breed would only be economical if there was a drastic reduction in wool profitability.

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