OPTIMAL DEVELOPMENT OF THE AUSTRALIAN SHEEP GENETIC RESOURCES

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SUMMARY

The Australian sheep industry is at a crossroads where technical opportunities allow rapid genetic change, and market developments tend to favour a shift in profitability from wool to meat production. A key question is how the existing genetic resources should be developed optimally to maximize future profitability across the Australian sheep industry. Breeding objectives need to be developed jointly for wool and terminal sire breeds, taking into account the joint use of these breeds in a crossbreeding system. A simple model was trialed, optimizing profit per unit of feed, suggesting that a crossbreeding system remains in place with specialized wool and meat breeds. Optimal development involves increased body size for meat breeds but increased wool production and quality and decreased body size for wool breeds that also serve as dams of prime lambs. Both wool and meat breeds should increase reproductive rate.

Keywords: sheep genetic resources, breeding objectives, breeding programs, wool and meat production

INTRODUCTION

The sheep industry has a prominent place in Australian history and is still of major socio-economic importance for the rural areas throughout Australia. The sheep industry is characterised as extensive with little capital investment at the producers end, and therefore potentially vulnerable. Like any other industry, its survival will depend on its power to remain competitive for its two main product areas, wool and meat. The competitive position of wool has rapidly declined in the past decades, due to the emergence of cotton and synthetics fibers. The sheep meat domestic market share has stopped its decline and sheep meat exports have increased strongly in the last decade, which has been attributed for a considerable part to the rapid genetic improvement in that sector (Banks et al, 2002). Because of the extensive nature of sheep production, being mainly pasture based, genetic improvement of the sheep flock is one of the major routes to productivity increase, as illustrated by the sheep meat case.

Wool and meat production have traditionally developed quite separately, in terms of production units and production regions, with the main common denominator being the Merino breed serving as a maternal resource for lamb production. In essence, lamb production originally developed as a by product from the Merino flock. Current market trends show an increased importance of lamb and declining terms of trade for wool. Australian sheep numbers have rapidly declined in the last 10 years, from 180 million in 1995 to 95 million in 2004, and the proportion of Merinos has declined from 95% to 85%. An important question in relation to these trends is not only the proportion of

Merinos in the flock, but more broadly the role of different sheep breeds in wool and meat production, and the extent to which wool and meat can be optimally combined in one production and breeding system. The proportion of terminal sire matings to Merino ewes has increased from 15 to 45 % between 1990 and 2002. There are some important questions about further genetic development. For example, to what extent should Merino breeders focus on increasing lambing rate and meat production ability? And to what extent is a crossing system with specialized wool and meat breeds more competitive than a breeding system geared towards producing dual purpose animals?

The aim of this paper is to discuss and explore the potential for genetic development of the Australian sheep flock under varying market scenarios. The main problem to be addressed is to jointly develop optimal breeding objectives for wool and meat breeds, accounting for their usage in crossbreeding. A relatively simple model study will be used to explore the major factors.

MATERIALS AND METHODS

One wool breed and one meat sheep breed were simulated, broadly representing current genetic resources in Australia. Three trait groups were considered, approximating the main profit drivers: wool- and meat production and reproduction. Each of these trait groups was constructed as an index of the different traits currently considered in industry selection indexes. The wool trait was based on an 18% micron premium ram power index with fleece weight, fiber diameter, staple strength, CV of fiber diameter and mature body weight. The meat trait was based on the Carcass Plus index including weight, fat and muscle measured close to slaughter age. Variances of, and correlations between, trait groups were based on economic and genetic parameters of these respective indexes (Table 1). Note that relationships between indexes can differ from correlations between aggregate true breeding values because information varies between component traits. For example, the reproduction EBV was mainly based on parental information. Response to selection for each trait was predicted as $b'G/\sqrt{(b'Pb)}$ where b are the selection weights, G = cov(X,g) and P = var(X), where X refers to the vector of index values (selection criteria) and g to true aggregate breeding values for each trait group. A Differential Evolution algorithm (Storn and Price, 1995) was used to derive jointly optimal weights for traits in the wool and meat breed. For a given set of weights, a 20 year response was predicted. An optimum breeding system (either crossbred or purebred) was derived with only one system being optimal for a given set of breed means and prices. When evaluating the profit of a crossbreeding system maintenance of purebreds was accounted for.

RESULTS

Profit of the base situation and optimally developed breeds is given in Table 2 for three different price scenarios. With the current price ratio ($12/kg clean fleece weight and $1.20/kg BW at slaughter) optimal selection develops the wool and meat breeds divergently, but both breeds are selected for improved reproductive rates. When the wool/meat price ratio declines the selection emphasis on reproductive rates increases. In the ultimate case where the price ration decreases by 50%, it becomes more profitable to simply focus on one meat breed.

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

	SD Index[1]	SD_BV[1]	accuracy	Correlations[2]		
				wool	meat	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
repro	0.53	1.27	0.17	0.05	0.28	1.00

[1] Unit of indexes is dollar per ewe
[2] Correlation between indexes above diagonal, correlations between breeding values below diagonal

Table 2. Optimal development of wool and meat breeds under different price scenarios

wool/meat price ratio		wool breed			meat breed			optimal system	relative profit	%wool
		wool	meat	repro	wool	meat	repro			
12/1.2										
	current mean	4.5	40	0.9	3	50	1.2	PxM	1.00	54
12/1.2	weights	1.00	-3.52	15.20	1.00	78.7	23.0			
	mean 20yrs	5.4	30.1	1.04	2.9	72.5	1.46	PxM	1.37	55
10/1.2	weights	1.00	-2.35	11.46	1.00	58.6	56.6			
	mean 20yrs	5.3	33.3	1.11	2.9	72.2	1.49	PxM	1.25	50
8/1.5	weights				1.00	1.75	24.9			
	mean 20yrs				3.3	65.1	1.65	PxP	1.40	14

Note: Selection weights are derived relative to the weight for wool. Units of trait means are related to profit per dry sheep unit, but scaled back to physical values: wool 'fleece weight' and meat 'body weight'. Repro = number of lambs weaned per ewe. The optimal system is either PxM ("Poll Dorset sires x Merino dams) or purebred PxP

DISCUSSION

Developing the appropriate breeding objective is critical to any genetic improvement program. With the markets driving profitability from wool to meat, especially the Merino industry is at a crossroads of how to develop further. There is a tendency to improve meat production ability. However, selection for meat related traits is likely to increase body weight. The model study, although simple, indicates that in an optimal system crossbreeding is used where lamb mothers produce wool and should maintain a relatively low body weight, because more animals can produce wool for a given feed resource. A similar result was found by Pitchford (2004). A key component of optimal development of (cross) breeding systems hinges on the value of mature weight, esp. of the wool breeds. A more detailed analysis of the economic value of mature bodyweight in such production systems is needed. In this study composite traits were used rather than component traits. In practice, meat value can possibly be improved without improving body weight and wool productivity can develop through two main components (weight and quality) that are unfavorably correlated. A more detailed modeling of traits is needed (e.g. see Meszaros, 1999) as well as a wider consideration of genetic resources (e.g. different types of Merino) and breeding systems (e.g. breed replacements and three way crosses that include maternal breeds). Furthermore, genetic parameters were not varied in this study and correlations between the three trait groups are likely to be important when deriving optimal development of breeds.

Genetic improvement in sheep has an enormous potential. The meat sheep sector has shown amazing genetic change in the last decade and this has translated into improved market share and strong profitability. The industry has taken up objective measurement and selection based on EBV and successful young sire programs are key drivers in genetic change (Banks et al, 2002). The Merino industry has on average made less progress. However, large increases in subscribers to formal genetic evaluation systems have occurred in recent years. For example, Merino Genetic Services has more than doubled the number of animals in their database over the last two years with now more than 0.5M animals. The Australian Sheep Genetics Database will contain over 0.8M Merinos (A.Ball, pers. comm.). Hence, the genetic evaluation technology is not only well developed in Australia but is becoming well adopted across the sheep industries.

Market uncertainty might make it difficult to determine the right objectives. Responsiveness of different systems to market changes could be modeled in further study. Generally, multiple trait selection is sensitive to economic values when traits have unfavorable correlations. For example, with high micron premiums selection for decreased fiber diameter is favored whereas with decreased premiums the emphasis should be on more fleece weight. However, in such a case risk can be avoided by developing two divergent lines because a cross of such lines will be close to the merit of a line (breed) that would have been selected in an intermediate direction (B. Kinghorn, personal communication). A similar situation can be imagined when selection is for meat and wool. Based on current parameters, the genetic correlation between wool and meat indexes is close to zero (Table 1) and correlations might not be unfavorable. However, there is limited knowledge about possible trade-offs between meat and wool production and initial CRC research has shown that they do exist (Adams et al, 2005). The reason for separate wool and meat breeds is more driven by the fact that these traits are expressed at different levels (ewes and progeny). Current crossbreeding systems are relatively less sensitive to economic values and only for a quite drastic reduction in wool profitability would a replacement by a single ‘dual purpose’ breed make economic sense under Australian conditions. Comparison with New Zealand systems, where dual purpose breeds are successfully kept with higher reproductive rates might be useful.

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