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MERINO BREEDING OBJECTIVES UNDER CLIMATE CHANGE

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SUMMARY

Breeding objectives were constructed for Merino enterprises operating in environments subject to forecast climate changes to 2030. These were derived using gross margins per dry sheep equivalent (DSE) from the GrassGro pasture model at three locations in New South Wales, Yass, Woolbrook, and Narrandera, and two enterprises, wool and dual purpose. Gross margins were predicted to be lower under forecast climate change, particularly at Narrandera. Simple breeding objectives were derived using GrassGro data, and selection index predictions based on these showed that losses in profitability could mostly be offset, and improved. The GrassGro breeding objectives were strongly correlated with those currently used in the MERINOSELECT genetic evaluation system, although there were differences in outcomes for body weight.

INTRODUCTION

The potential impact on future pasture production from increased temperatures and a more variable rainfall pattern has been assessed by the Southern Livestock Adaption 2030 project (sla2030.net.au). Even when the predictions are for minor changes in rainfall, increases in temperature result in a decrease in soil moisture leading to a decline in pasture production, both quantity and quality. Combined with a predicted increase in the number and severity of dry events, breeding flocks will likely have to adjust stocking rates downwards to manage the increased pressure on the pasture base, or utilise more conserved feed. If these adjustments are not made there will be an increase in the loss of perennial species from the system. The reduced use of fertiliser through the high rainfall zone of Australia adds to the pressure from climate change. Under these conditions it is relevant to ask what the appropriate breeding directions for livestock production are. In this paper, we use the GrassGro pasture model (Moore *et. al.* 1997) to estimate gross margins for Merino sheep enterprises under predicted climatic conditions. We then derive simple breeding objectives targeting these climate scenarios and compare them to the indexes currently used by the Merino industry

MATERIALS AND METHODS

GrassGro enterprise modelling: GrassGro was used to model pasture production of annual and perennial species in three locations in New South Wales, using local soil and daily weather records from 1960 to 2013. The locations were Yass (stocking rate between 1960 and 2013 of 14.2 DSE/ha), Woolbrook (13 DSE/ha), and Narrandera (4.7 DSE/ha). Pasture production to 2030 was then modelled using climate predictions of temperature and rainfall from the HadGEM2 Global Circulation Model (Jones *et al.* 2013) with stocking rates set with a restriction to maintain a minimum acceptable ground cover. These were 10 DSE/ha at Yass, 9.3 DSE/ha at Woolbrook, and 3.1 DSE/ha at Narrandera. Two different Merino enterprises were compared at each location, a wool system and a dual purpose system with all ewes mated to terminal sires and lambs finished in a feedlot. Production means for ewe fleece weight (agfw, kg), fibre diameter (afd, microns), body weight (awt, kg), and number of lambs weaned (nlw, lambs per ewe joined) are shown in Table 1.

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Gross margins ($/DSE) were calculated within GrassGro based on these production means, and median price and cost figures from 2009 to 2013.

Table 1: Trait means for Wool and Dual Purpose (DP) enterprises at Yass, Woolbrook and Narrandera

Trait	Yass		Woolbook		Narrandera	
	Wool	DP	Wool	DP	Wool	DP
agfw (kg)	5.3	5.5	3.2	5.5	6.0	5.5
afd (μ)	18.6	19.5	17.3	19.5	20.0	19.5
awt (kg)	52	55	47	55	58	55
nlw (lambs)	1.02	0.98	0.84	1.01	1.08	1.08

Breeding objectives for future pasture production: Starting from these base scenarios, relative economic values were calculated for each trait by independently increasing the mean by 5% and re-running GrassGro to obtain a new gross margin. These were deviated from the base gross margin and converted to a unit change for each trait (on the scale of MERINOSELECT breeding values) to obtain final relative economic values.

Responses to selection on indexes for these breeding objectives were predicted over a 15 year time horizon for a ram breeding program with 300 ewes mated to 10 rams annually, selection intensities of 0.78 and 1.99 in females and males, and generation intervals of 4.5 and 3 in males and females. Two sets of selection criteria were compared: base traits including fleece weight, fibre diameter, CV of diameter, and body weight, and base traits plus number of lambs weaned.

Comparison with modified MERINOSELECT objectives: MERINOSELECT provides standard indexes for three breeding objectives: Dual Purpose (DP+), based on a meat-focussed production system where surplus progeny are sold as lambs and a portion of ewes are joined to terminal sires; Merino Production (MP+) based on a balanced wool and meat production system where surplus progeny are sold as hoggets; and Fibre Production (FP+) based on a wool focussed production system. Importantly, the objectives feature reducing emphasis on body weight from DP+ to MP+ to FP+. They also differ in the level of emphasis placed on fibre diameter. DP+ is designed to increase fleece weight while maintaining fibre diameter, MP+ balances increased fleece weight and reduced fibre diameter, while FP+ targets large reductions in fibre diameter while holding fleece weight constant.

Genetic correlations between GrassGro and MERINOSELECT breeding objectives were calculated as $a_1'Ca_2/\sqrt{(a_1'Ca_1.a_2'Ca_2)}$, where a_1 and a_2 are vectors of relative economic values for GrassGro and MERINOSELECT objectives and C is the genetic covariance matrix between traits in the objectives. The MERINOSELECT objectives include traits which cannot be modelled by GrassGro, including carcass traits in DP+, worm egg count in FP+, and staple strength in all three. Economic values for these traits were not included when calculating correlations. The comparison is therefore based on modified MERINOSELECT breeding objectives containing equivalent traits to those modelled by GrassGro.

RESULTS AND DISCUSSION

Gross margins per DSE for the base production system parameters are shown in Table 2 for the period 1960 – 2013, and in 2030 under predicted climate changes. Profitability was predicted to be lower under forecast climate change for all locations and production systems, but particularly at Narrandera. Also shown are gross margins for 2030 where each trait mean was independently changed by 5%. For fleece weight, fibre diameter, and number of lambs weaned, the trait changes always led to an increase in profitability. By contrast, increasing body weight by 5% reduced profitability in wool systems at all three locations, and for the dual purpose system at Woolbrook.

For dual purpose systems at the other sites, increasing body weight had a neutral effect on profitability at Yass, and a positive effect at Narrandera. Note that gross margins were considerably higher for dual purpose systems because it was only possible to model a system where all ewes were mated to terminal sires, and the results do not incorporate the cost of replacing the ewe flock.

Table 2: Gross margins ($/DSE) for base production systems from 1960 to 2013, with predicted climate changes in 2030, and 2030 with each trait mean changed by 5%.

Period/Trait	Yass		Woolbrook		Narrandera	
	Wool	DP	Wool	DP	Wool	DP
			Gross margins ($/DSE)			
1960 – 2013	19.93	28.75	15.69	30.22	16.17	22.60
2030	18.60	28.16	14.41	29.81	9.36	13.45
+ 5% agfw	20.00	29.52	15.81	31.07	10.65	14.41
- 5% afd	19.90	29.90	17.31	31.17	10.65	15.17
+ 5% awt	18.00	28.19	13.87	29.63	8.33	15.17
+ 5% nlw	19.20	29.03	14.95	30.38	10.33	15.17

Predicted trait and gross margin responses from index selection on the GrassGro-derived objectives are shown in Table 3. Improvements in gross margin ranged from $3.58 to $6.88 per DSE, and were large enough to offset and improve on the loss in profitability predicted due to climate change at Yass and Woolbrook, but not at Narrandera. For wool traits, most systems resulted in balanced improvement of fleece weight and fibre diameter, the exceptions being the wool system at Woolbrook in which there was a greater emphasis on fibre diameter, and the dual purpose system at Narrandera in which a large increase in body weight limited the gain in fleece weight. There were large reductions in body weight for all wool systems (-2.14 to -2.93kg), consistent with negative economic values in these systems. In dual purpose systems there were smaller reductions at Woolbrook (-0.70 to -0.81kg), little change at Yass (0.07 to 0.27kg), and large increases at Narrandera (4.11 to 4.85kg), once again consistent with the respective economic values. When base traits only were recorded and included in the selection index, number of lambs weaned decreased for all systems except dual purpose at Narrandera. By contrast, when number of lambs weaned was recorded, changes in the trait were either neutral or positive for all systems (0.0 to 0.08 lambs), and gross margin was increased by small to moderate amounts.

Table 3: Trait and gross margin (GM, $/DSE, in the predicted 2030 environments) responses after 15 years of selection with base and base+nlw selection criteria

Criteria	Trait	Yass		Woolbrook		Narrandera	
		Wool	DP	Wool	DP	Wool	DP
base	agfw	8.29	6.45	1.34	8.19	6.97	1.04
	afd	-0.92	-1.19	-1.77	-1.00	-1.04	-0.62
	awt	-2.14	0.27	-2.14	-0.70	-2.93	4.85
	nlw	-0.03	-0.01	-0.02	-0.02	-0.04	0.04
	profit	4.06	4.05	6.82	3.58	3.78	5.73
+nlw	agfw	7.95	6.03	1.37	7.85	6.20	1.06
	afd	-0.86	-1.08	-1.74	-0.93	-0.88	-0.53
	awt	-2.18	0.07	-2.19	-0.81	-2.78	4.11
	nlw	0.00	0.03	0.00	0.01	0.02	0.08
	profit	4.21	4.32	6.88	3.72	4.23	6.42

Genetic correlations between GrassGro and the reduced MERINOSELECT breeding objectives (Table 4) generally show a high degree of association, indicating that the industry indexes will select sheep that increase profit under the predicted climatic conditions. For wool systems, the FP+ objective showed the highest correlations, and this was because it has the lowest level of emphasis on body weight and is therefore best aligned with objectives which have a negative emphasis on the trait. The MERINOSELECT objectives were more highly correlated with dual purpose systems, again because of the (increased) level of emphasis on body weight in these. The DP+ objective was most highly correlated with the dual purpose system at Narrandera. It is clear from these results that the key difference between the two approaches (GrassGro and MERINOSELECT) is their treatment of the impact of body weight on profitability. In the GrassGro model, body weight is considered as a single trait, while in the MERINOSELECT model body weight is separated into yearling and mature body weight, with the former targeting improved growth rates in sale lambs. The MERINOSELECT model does account for the cost of feed, and the outcome of this is that economic values are typically positive for yearling weight and negative for mature weight, but because genetic correlations between ages are strongly positive overall genetic gains for body weight are most often positive. We also note that because the GrassGro and MERINOSELECT objectives model feed in different ways, it may be difficult to resolve the differences in the treatment of body weight.

Table 4: Genetic correlations between GrassGro and reduced MERINOSELECT breeding objectives

Objective	Yass		Woolbrook		Narrandera	
	Wool	DP	Wool	DP	Wool	DP
DP+	0.76	0.91	0.55	0.82	0.85	0.94
MP+	0.82	0.94	0.67	0.89	0.86	0.89
FP+	0.89	0.97	0.87	0.94	0.88	0.82

CONCLUSIONS

The pasture modelling presented here shows that the future profitability of sheep enterprises will be lower under predicted climate change, but that in some locations genetic improvement programs can offset and to a degree exceed the loss in profit. Current MERINOSELECT breeding objectives are relatively well aligned with the genetic change required, but further work is required to understand the effects of body weight, and in particular to fully understand the biological and economic effects of reducing body weight at some or all stages of the productive lifetime of animals.

REFERENCES

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