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CURRENT FLOCK EFFECTS ON LIFETIME REPRODUCTIVE PERFORMANCE OF SIMULATED SELECTION AT HOGGET AGE IN MERINO SHEEP, FOR FLEECE WEIGHT, FIBRE DIAMETER, BODY WEIGHT AND RELEVANT SELECTION INDEXES. III. HIGH RAINFALL REGION RESULTS.

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SUMMARY

The effects of simulated selection at hogget age for fleece weight, fibre diameter, body weight and two relevant selection indexes on lifetime fertility, litter size, lamb survival and reproduction rate have been examined for a medium-wool random breeding flock of Merino sheep grazing in the New England tablelands of NSW. Simulated single trait selection for increased fleece weight, fibre diameter, and body weight had significant positive effects on lifetime fertility ($P<0.05$; $P<0.01$; $P<0.01$ respectively), litter size ($P<0.001$; $P<0.001$; $P<0.001$ respectively) and reproduction rate ($P<0.001$; $P<0.001$; $P<0.001$ respectively)). There were no significant effects on lifetime reproduction rate or on any of the component traits, of simulated selection for either of the two selection indexes. Despite the substantial range in yearly mean reproduction rate (0.55 to 1.09), the selection group x lambing year effect was not significant for any combination of the reproduction and production traits and there was no tendency for the selection group differences in reproduction rate to increase or decrease over the observed range in mean reproduction rate. These data reinforce the findings from earlier papers in this series and do not support the view that selection for increased fleece weight may adversely affect lifetime reproduction rate.

INTRODUCTION

Adams *et al.* (2006) have suggested that reproductive performance may potentially be compromised in animals with increased capacity for wool production especially if feed supplies are reduced. To examine the genetic consequences of selection for increased fleece weight on reproduction rate, in an environment where feed supplies are regularly compromised, Piper *et al.* (2007) analysed data from long term fleece weight selection and control flocks of medium-wool Merino sheep grazing at Cunnamulla, south west Queensland. Rainfall at Cunnamulla averages 375 mm *per annum* but there is considerable variation and rainfall unreliability is the main factor limiting feed supply from pasture. In this environment, the selected lines fleece weight increased at about 2 % per year but as expected did not change in the control line. There was no change in lifetime reproduction rate in either the selection or control lines. The authors concluded that “long term breeding programs for Merino sheep, which include increased fleece weight as a component of the breeding objective, can be implemented without necessarily reducing reproduction rate.”

To examine the effects on ewe lifetime reproduction rate of simulated phenotypic selection for wool and body traits, Piper *et al.* (2009) analysed data from a random mating flock grazing at Cunnamulla, Queensland. In this relatively harsh, semi-arid environment, there were no significant effects on lifetime reproduction rate or on any of the component traits (fertility, litter size, lamb survival), of simulated selection for fleece weight, fibre diameter or either of the selection indexes. Simulated selection for body weight had a significant positive effect on lifetime litter size ($P<0.001$) and an almost significant positive effect on lifetime reproduction rate ($P=0.059$). In a follow up study, Piper *et al.* (2011) demonstrated that the effect of simulated selection for production traits on lifetime reproductive performance was not significantly influenced by variability in the available feed resources as assessed by the year to year variation in mean reproduction rate. In this paper, we have applied the same analysis to a much larger data set collected on a medium Peppin Merino flock grazing in a high rainfall region at Armidale, NSW.

MATERIALS AND METHODS

Sheep. The reproductive performance of 2248 medium-wool, mixed Peppin origin, Merino ewes, first mated at around 18 months of age (mo) between 1970 and 1986, was analysed. There were 8293 records for fertility (ewes lambing/ewe joined, EL/EJ), 7135 for litter size (lambs born/ewe lambing, LB/EL), 7126 for lamb survival (lambs weaned/lamb born, LW/LB) and 8284 for reproduction rate (lambs weaned/ewe joined, LW/EJ). Details relating to the origin of the flock, to the environment and management of the flock at CSIRO's Longford Field Station, Armidale, NSW, have been given by Turner and Jackson (1978). The mating design for the flock consisted of 20 sire groups each of 20 mixed age ewes. Replacement sires were mated in the clockwise adjacent mating group to that in which they were born and ewe replacements were distributed at random to the mating groups with the restriction that mating of close relatives was avoided.

Observations and data analysis. Ten wool and body characteristics were measured on all animals using the techniques described by Turner *et al.* (1953). For these analyses, the data comprises measurements of greasy fleece weight (GFW), fibre diameter (FD), and body weight (BWT) taken from 12-14 mo ewes and the reproduction records (fertility, litter size, lamb survival, and reproduction rate) of the same ewes at their first five lambings (aged 2-6 years).

Allocation of ewes to High (H) and Low (L) selection groups for the production traits. As described by Piper *et al.* (2009), linear models adjusting for significant fixed effects were fitted using the statistical software R (R Development Core Team, 2011). For GFW and BWT these effects included contemporary group defined as year of birth by management-flock subclasses, birth type, and rearing type, all fitted as factors. Age of dam (years) and age of measurement (days) were fitted as covariates, including a quadratic term for age of dam. For FD, only contemporary group and birth type were significant.

Residual values from these single trait models were used to allocate animals to High and Low trait groups within each year of birth, thus simulating current flock selection. Animals with residual values superior to the median value for the year were allocated to the High group, and those with values inferior to the median were allocated to the Low group. The mean difference in performance between the High and Low groups (H-L) for each trait is shown in Table 1.

Table 1. Predicted means for, and differences between the High and Low groups for GFW (kg), CFW (kg), FD (micron), BWT (kg), and Merino 7% and 14% indexes (M7 and M14)

	High (se)	Low (se)	H-L(se)	(H-L)/L*100
GFW	3.56 (0.01)	2.87 (0.01)	0.69 (0.01)	24.0
FD	22.01 (0.04)	19.60 (0.03)	2.41 (0.04)	12.3
BWT	35.39 (0.08)	30.17 (0.08)	5.21 (0.09)	17.3
M7	104.69 (0.14)	95.59 (0.14)	9.10 (0.15)	9.5
M14	105.97 (0.18)	94.41 (0.18)	11.56 (0.19)	12.2

The residual values for fleece weight and fibre diameter were also used to calculate selection indexes for the Merino 7% and 14% breeding objectives used by MERINOSELECT (Swan *et al.* 2007). Selection index weights were derived for these objectives using MERINOSELECT relative economic values and genetic parameters, assuming the measurements available included own performance for greasy fleece weight and fibre diameter. The index weights (dollars per ewe) for greasy fleece weight and fibre diameter were 9.8 and -3.6 for the Merino 7% objective, and 5.9 and -5.1 for the Merino 14% objective. Animals were allocated to High and Low index groups within year of birth using the procedure described above for individual traits. Differences in performance for the two indexes are shown in Table 1.

Analyses of the reproduction data. Repeated record mixed linear models, adjusting for fixed effects were fitted using ASReml (Gilmour *et al.* 2006). The effects fitted included lambing year, management group, lambing year x management group, birth type, age of dam (years), own age (years), selection group (High or Low) and lambing year x selection group all fitted as factors with ewe fitted as a random effect. Lambing year (P<0.001), management group (P<0.001 to P<0.053), lambing year x management group (P<0.001 to P<0.057) and own age (P<0.001 to P< 0.002) were significant or nearly so for all combinations of reproduction and production traits. Age of dam was significant (P<0.05) for each of the reproduction rate (LW/EJ), production trait combinations but not for any other combination of reproduction and production traits. Birth type was not significant for any combination of the reproduction and production traits.

RESULTS AND DISCUSSION

The predicted mean values for the High and Low groups for each production trait by reproduction trait combination are shown in Table 2. For GFW the difference between the high and low groups (H-L) was positive and significant for fertility (2.2%; P<0.05), litter size (4.4%; P<0.001) and reproduction rate (6.6%; P<0.001). For FD and BWT the difference between the high and low groups (H-L) was positive and significant for fertility (2.6%; 2.6%; P<0.01), litter size (3.2%; 7.0%; P<0.001) and reproduction rate (6.2%; 10.2%; P<0.001). There were no significant differences between the H and L groups for any of the production traits for survival and no differences between the H and L, M7 or M14 index groups for any of the reproduction traits. As found in Piper *et al.* (2009), the simulated selection for increased body weight produced a significant increase (P<0.001) in litter size but in the current study, it also produced a significant increase in fertility (P<0.01) and reproduction rate (P<0.001). Also in contrast to the results of Piper *et al.* (2009), there were positive and significant differences between the high and low GFW and FD groups for fertility, litter size and reproduction rate. These differences between the high and low groups for GFW and FD tend to balance each other in their contributions to the M7 and M14 indexes. This balancing effect probably accounts for the lack of difference between the high and low M7 and M14 groups for any of the reproduction traits.

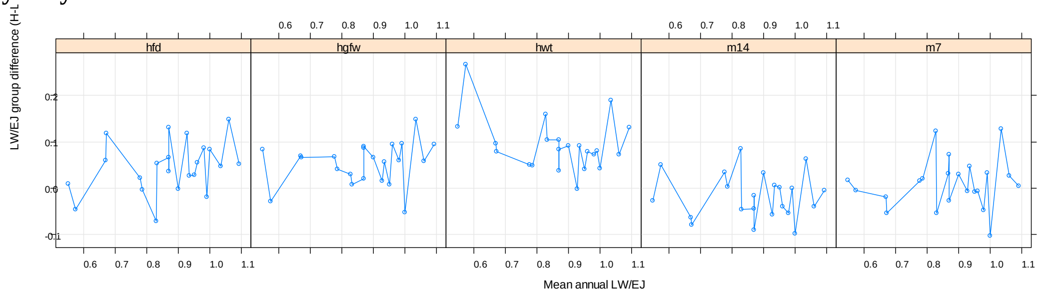
Table 2. **Predicted mean values (se) for the high (H) and low (L) groups for each production trait by reproduction trait combination**

	Fertility (EL/EJ)	Litter Size (LB/EL)	Survival (LW/LB)	Rep.Rate (LW/EJ)
GFW - H	0.883 (0.006) *	1.278 (0.009) ***	0.841 (0.006)	0.930 (0.011) ***
GFW - L	0.864 (0.006) *	1.225 (0.009) ***	0.847 (0.006)	0.872 (0.011) ***
FD - H	0.885 (0.006) **	1.272 (0.009) ***	0.846 (0.006)	0.928 (0.011) ***
FD - L	0.862 (0.006) **	1.232 (0.009) ***	0.842 (0.006)	0.874 (0.011) ***
BWT - H	0.885 (0.006) **	1.294 (0.009) ***	0.846 (0.006)	0.944 (0.011) ***
BWT - L	0.862 (0.006) **	1.209 (0.009) ***	0.842 (0.006)	0.857 (0.011) ***
M7 - H	0.880 (0.006)	1.258 (0.009)	0.838 (0.006)	0.904 (0.011)
M7 - L	0.868 (0.006)	1.247 (0.009)	0.851 (0.006)	0.898 (0.011)
M14 - H	0.870 (0.006)	1.245 (0.009)	0.840 (0.006)	0.889 (0.011)
M14 - L	0.877 (0.006)	1.259 (0.009)	0.848 (0.006)	0.914(0.011)

Significance of difference between high and low groups; * P<0.05; ** P<0.01: *** P<0.001; remainder, ns

The yearly mean LW/EJ ranged from 0.55 in 1976 to 1.09 in 1987. The differences in LW/EJ between the High and Low selection groups for each production trait in each year are shown in Figure 1 plotted against the yearly mean LW/EJ. There is clearly no tendency for the production trait differences in LW/EJ to increase or decrease as the mean LW/EJ moves from 0.55 to 1.09 and, despite the substantial range in mean LW/EJ, the lambing year x selection group effect was not significant for any combination of the reproduction and production traits.

Figure 1. Yearly production trait group differences (H-L) in LW/EJ plotted against the yearly mean LW/EJ



CONCLUSIONS

The results from Piper *et al.* (2009, 2011) on the phenotypic consequences of simulated selection for production traits on reproductive performance did not support the view that sheep with increased capacity for wool production may have reduced reproductive performance when variable feed availability challenges animal production from pasture. The results from this study, on a much larger flock grazing in a very different production environment, reinforce that conclusion. These current findings are again broadly consistent with published estimates of the phenotypic correlations among the traits examined.

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