Proc. Assoc. Advmt. Anim. Breed. Genet. 19:335-338

EFFECTS ON LIFETIME REPRODUCTIVE PERFORMANCE OF PHENOTYPIC SELECTION FOR FLEECE WEIGHT, FIBRE DIAMETER, BODY WEIGHT AND RELATED SELECTION INDEXES. II. SELECTION GROUP X ENVIRONMENT INTERACTION.

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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 south west Queensland. There were no significant effects on lifetime reproduction rate or on any of the component traits, of selection for fleece weight, fibre diameter or either of the two selection indexes. 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 ($p=0.060$). Despite the substantial range in yearly mean reproduction rate (0.69 to 1.01), 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 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 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, Hatcher and Atkins (2007) analysed data from the medium-wool strain of the Trangie QPLUS flock (Taylor and Atkins 1997). They found that within-flock selection for (i) body weight would lead to significant improvements in reproductive performance, for (ii) fibre diameter would have no significant effects on reproductive performance and for (iii) fleece weight would lead to fewer progeny surviving to weaning. The data analysed by Hatcher and Atkins (2007) came from four flocks undergoing long term selection for a range of micron premium breeding objectives and from a related control flock. It is not clear whether the correlated reproductive performance results may have been influenced by including data from the four long term selection flocks where the breeding objectives and selection indexes included the traits fleece weight, fibre diameter and body weight. In the first paper of this series, 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 this second paper, we re-analyse the data presented by Piper *et al.* (2009) to examine whether there is any evidence that the effect of simulated selection for production traits on lifetime reproductive performance may be influenced by variability in the available feed resources as assessed by the year to year variation in mean reproduction rate.

MATERIALS AND METHODS

Sheep. The reproductive performance of 615 medium-wool, mixed Peppin origin, Merino ewes, first mated at around 18 months of age (*mo*) between 1950 and 1964, was analysed. The mating design for the flock has been described by Turner *et al.* (1968) and the environment and management of the flock at the CSIRO National Field Station, Gilruth Plains, Cunnamulla, Queensland, has been described by Turner *et al.* (1959).

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 18 *mo* ewes (previously shorn at 6 *mo*) and the reproduction records (fertility, ewes lambing/ewe joined, EL/EJ; litter size, lambs born/ewe lambing, LB/EL; lamb survival, lambs weaned/lamb born, LW/LB; and reproduction rate, lambs weaned/ewe joined, LW/EJ) of the same ewes at their first six lambings (aged 2-7 years). Wool and body measurements and most of the reproduction records were obtained at Gilruth Plains. Some of the later reproduction records for the 1961 to 1964 drop ewes were obtained at CSIRO's Longford Field Station, Armidale, NSW.

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, 2008). 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), FD (micron), BWT (kg), and the Merino 7% and 14% indexes (M7 and M14)

	High (se)	Low (se)	H-L	(H-L)/L*100
GFW	3.89 (0.04)	3.25 (0.04)	0.64	19.6
FD	23.19 (0.15)	20.61 (0.15)	2.58	12.5
BWT	32.80 (0.28)	27.97 (0.28)	4.83	17.3
M7	105.31 (0.46)	94.54 (0.47)	10.77	11.4
M14	106.59 (0.59)	93.21 (0.60)	13.38	14.4

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, management group and the lambing year x management group interaction were significant ($P<0.001$ to $P< 0.013$) for all combinations of reproduction and production traits. Own age was significant ($P<0.001$) for all combinations of production traits and the reproduction traits LB/EL and LW/EJ but not for any of the production trait combinations with EL/EJ or LW/LB. Birth type and age of dam were not significant for any combination of the reproduction and production traits.

RESULTS AND DISCUSSION

The number of observations for each of the reproduction trait analyses was 2461 for fertility, 2185 for litter size, 2177 for lamb survival and 2454 for reproduction rate. The predicted mean values for the High and Low groups for each production trait by reproduction trait combination are shown in Table 2. They differ in very minor detail from those in Table 2 of Piper *et al.* (2009) as a consequence of the different and more comprehensive analysis model used in this study. However, the outcome is the same as in Piper *et al.* (2009). With two exceptions, there were negligible effects of simulated selection for production traits on subsequent lifetime reproductive performance. As found in Piper *et al.* (2009), the exceptions were that simulated selection for increased body weight produced a significant increase ($p<0.001$) in litter size and an almost significant increase ($p=0.060$) in reproduction rate.

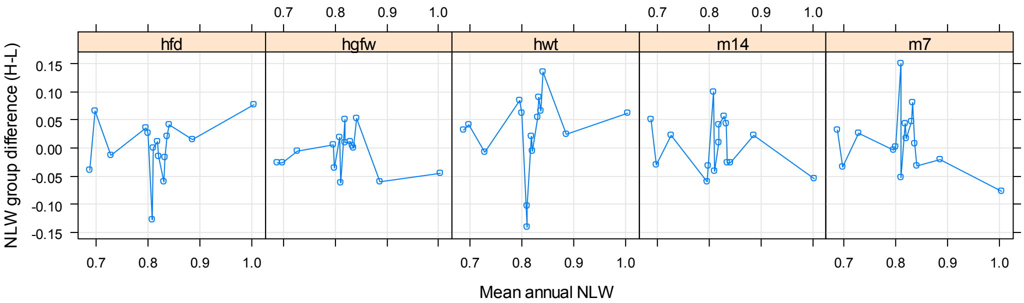
Table 2. **Predicted mean values (se) for the high and low groups for each production trait by reproduction trait combination**

	Fertility (EL/EJ)	Litter Size (LB/EL)	Survival (LW/LB)	Rep Rate (LW/EJ)
GFW - H	0.90 (0.01)	1.14 (0.01)	0.77 (0.01)	0.81 (0.01)
GFW - L	0.90 (0.02)	1.13 (0.01)	0.78 (0.01)	0.82 (0.01)
FD - H	0.91 (0.01)	1.14 (0.01)	0.78 (0.01)	0.82 (0.01)
FD - L	0.89 (0.01)	1.13 (0.01)	0.78 (0.01)	0.81 (0.01)
BWT - H	0.90 (0.01)	1.17 (0.01) ***	0.77 (0.01)	0.83 (0.01) †
BWT - L	0.90 (0.01)	1.10 (0.01) ***	0.79 (0.01)	0.80 (0.01) †
M7 - H	0.90 (0.01)	1.13 (0.01)	0.78 (0.01)	0.81 (0.01)
M7 - L	0.90 (0.01)	1.14 (0.01)	0.78 (0.01)	0.81 (0.01)
M14 - H	0.90 (0.01)	1.13 (0.01)	0.78 (0.01)	0.81 (0.01)
M14 - L	0.90 (0.01)	1.14 (0.01)	0.78 (0.01)	0.81(0.01)

Significance of difference between high and low groups; *** P<0.001; † P=0.060; remainder, ns

The yearly mean (LW/EJ) ranged from 0.69 in 1968 to 1.01 in 1959. 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 0.69 to 1.01 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) and from this study, which both examined the phenotypic consequences of simulated selection for production traits on reproductive performance do 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. These current findings are again consistent with published estimates of the phenotypic correlations among the traits examined.

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