EFFECTS ON LIFETIME REPRODUCTIVE PERFORMANCE OF PHENOTYPIC SELECTION FOR FLEECE WEIGHT, FIBRE DIAMETER, BODY WEIGHT AND RELATED SELECTION INDEXES

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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 (EL/EJ), litter size (LB/EL), lamb survival LW/LB) and reproduction rate (LW/EJ) has been examined for a medium-wool random breeding control flock of Merino sheep grazing in south west Queensland. There were no significant effects on lifetime reproduction rate or any of the three 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 ($p=0.059$). These data do not support the view that phenotypic selection for increased fleece weight will have adverse effects on lifetime reproduction rate.

INTRODUCTION

A recent series of papers (Cloete *et al.* 2002; Greeff 2005; Adams *et al.* 2006) has suggested that reproductive performance may potentially be compromised in animals with increased capacity for wool production especially if feed supplies are reduced. To further examine this proposition, Piper *et al.* (2007) analysed data from long term selection and control flocks of medium-wool Merino sheep grazing at Cunnamulla in the semi-arid zone of south west Queensland. Rainfall in the Cunnamulla region averages about 375 mm *per annum* but there is considerable annual variation and rainfall unreliability is the main factor limiting feed supply from pasture. In 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 (LW/EJ) 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 a multi-trait breeding objective, can be implemented without necessarily reducing reproduction rate."

Hatcher and Atkins (2007) examined the effects of simulated phenotypic selection for hogget fleece weight, fibre diameter and body weight on lifetime reproduction rate and its components in ewes from the medium-wool strain of the Trangie QPLUS flock (Taylor and Atkins 1997). They found that within-flock selection for body weight would lead to significant improvements in reproductive performance, for fibre diameter would have no significant effects on reproductive performance and for 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 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 this paper, to avoid any possible influence on the results of including data from long term selection flocks, we have analysed data from a random mating control flock grazing in the relatively harsh semi-arid environment of the Cunnamulla district in south west Queensland. In the analyses reported below, we have examined the effects on lifetime reproduction rate and its components, of simulated phenotypic selection for fleece weight, fibre diameter, body weight and two related selection indexes.

MATERIALS AND METHODS

Sheep. The reproductive performance of 615 medium-wool Merino ewes, first mated at around 18 months of age between 1950 and 1964, was the focus of these analyses. The foundation ewes for this flock were typical medium-wool Merino ewes of mixed Peppin origin. 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 the purpose of these analyses, the data consists of 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 (EL/EJ), litter size (LB/EL), lamb survival (LW/LB), and reproduction rate (LW/EJ) of the same ewes at their first six lambings (aged 2-7 years). All of the wool and body measurements and most of the reproduction records were obtained at Gilruth Plains. The flock was transferred to the CSIRO Field Station, Longford, Armidale, NSW in 1966 and some of the later reproduction records for the 1961 to 1964 drop ewes were obtained at Longford.

Allocation of ewes to high and low groups for the production traits. 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 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 management group defined as year of birth by management-flock subclass, birth type, age of dam (years), own age (years) and group (high or low) all fitted as factors with ewe fitted as a random effect. Management group was significant (P<0.001) 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.

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	0.91 (0.01)	1.14 (0.01)	0.75 (0.01)	0.81 (0.01)
GFW - L	0.90 (0.02)	1.14 (0.01)	0.77 (0.01)	0.82 (0.02)
FD - H	0.91 (0.01)	1.14 (0.01)	0.76 (0.01)	0.82 (0.02)
FD - L	0.89 (0.01)	1.13 (0.01)	0.76 (0.01)	0.81 (0.02)
BWT - H	0.91 (0.01)	1.18 (0.01) ***	0.75 (0.01)	0.83 (0.02) †
BWT - L	0.90 (0.01)	1.10 (0.01) ***	0.77 (0.01)	0.80 (0.02) †
M7 - H	0.91 (0.01)	1.13 (0.01)	0.76 (0.01)	0.81 (0.02)
M7 - L	0.90 (0.01)	1.14 (0.01)	0.76 (0.01)	0.81 (0.02)
M14 - H	0.90 (0.01)	1.13 (0.01)	0.76 (0.01)	0.81 (0.02)
M14 - L	0.91 (0.01)	1.15 (0.01)	0.76 (0.01)	0.81(0.02)

Significance of difference between high and low groups.;. *** P<0.001; † P=0.059; remainder, ns

Inspection of the contrasting high and low group means for each production trait, reproduction trait combination in Table 2 shows that with only two exceptions, there were only negligible effects of simulated selection for production traits on subsequent lifetime reproductive performance. 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=0.059) in reproduction rate.

The differences between the high and low groups and the percentage difference between them (H-L/L*100) are shown in Table 3 for each production trait – reproduction trait combination. With the exception of the effects on litter size and reproduction rate of selection for body weight, the majority of the differences are less than one percent and there is no consistent pattern of positive or negative effects. These very small and non-significant effects of phenotypic selection for production traits on reproductive performance have occurred despite the highly significant and sizable effects of that simulated selection on the differences between the high and low groups for the production traits (Table 1).

These results confirm the findings of Hatcher and Atkins (2007) in respect of the positive effect of selection for body weight on reproductive performance and the lack of effect of simulated selection for fibre diameter on reproductive performance. However, in this study there was also no effect on reproductive performance of selection for fleece weight or of selection for optimal indexes (seven and fourteen percent micron premium) combining fleece weight and fibre diameter. If anything, the grazing environment at Cunnamulla would be expected to be somewhat more harsh or marginal than that at Trangie and the proposition that sheep with high potential for fleece production may be compromised in respect of reproduction rate when unfavorable feed conditions are more likely to occur (Adams *et al.* 2006) was not observed in this study.

Table 3. **Percentage differences (H-L/L*100) between the high and low groups for each production and reproduction trait combination.**

	Fertility (EL/EJ)	Litter Size (LB/EL)	Survival (LW/LB)	Rep Rate (LW/EJ)
GFW	0.42	0.13	-1.42	-1.19
FD	2.29	0.85	-0.34	1.03
BWT	0.13	6.62 ***	-0.82	3.85 †
M7	0.40	-1.03	0.62	0.41
M14	-0.50	-1.34	0.49	-0.34

Significance of difference between high and low groups; *** P<0.001; † P=0.059; remainder, ns

CONCLUSIONS

The results from this study, which examined the phenotypic consequences of simulated selection for production traits on reproductive performance and of the previous study (Piper *et al.* 2007) which focused on the genetic consequences of such selection, 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 consistent with published estimates of the phenotypic correlations among the traits examined.

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