WORM RESISTANCE IN A MERINO BREEDING OBJECTIVE - INFLUENCE OF GENETIC CORRELATIONS BETWEEN RESISTANCE AND PRODUCTION TRAITS

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SUMMARY

A desired gains approach was used to investigate the effect of placing varying emphasis on worm resistance in a Merino breeding objective. The sensitivity of predicted genetic gain was examined using two sets of assumed parameters and a range of desired gains for worm resistance. The outcome of assuming zero genetic correlations between production traits and faecal egg count (FEC), in a population where the best available estimates are the true parameters, was to under-estimate response in production and to change substantially the contribution of reproductive rate to the production index. Genetic change in FEC was over-estimated, particularly when the desired gain specified for FEC was low.

INTRODUCTION

The contribution helminth resistance will make to a breeding objective for Merino sheep is largely dependent on the heritability and relative economic value (REV) of resistance, as well as the genetic co-variances between resistance and production traits. The economic value of parasite resistance, as indicated by faecal egg count (FEC), is yet to be accurately estimated and will vary depending on level of parasite challenge and cost of adequate control strategies. To overcome this lack of knowledge, a desired gain is often assumed for FEC, which allows an implied REV to be calculated (Woolaston 1994). Effect of selecting for a desired gain in FEC can then be examined in terms of its impact on other traits in the breeding objective. The results of this type of analysis are sensitive to the genetic correlations between the restricted trait and the traits for which aggregate merit is maximised (Brascamp 1984). A common practice is to assume phenotypic and genetic co-variances of zero between production traits and FEC. However, some estimates of these parameters are now available (Eady 1996) and the consequences of assuming covariances of zero need to be investigated.

One approach to testing the sensitivity of genetic gain to changes in co-variances, is to compare genetic response under two scenarios. The first is to predict response when incorrect parameters are used such as, for example, zero genetic correlations between FEC and production. This prediction can then be compared with a second scenario where actual response is predicted for a population where incorrect parameters are used to determine selection policy, but where a different set of true parameters exist. The first step involves the straightforward prediction of response as given by the following equation:

$$\text{Response in selection index (\$)} = i\frac{b'G}{\sqrt{b'Pb}}a$$

where P = phenotypic co-variance matrix of selection criteria, G = genetic co-variance matrix for selection criteria and objective traits, i = selection intensity, a = vector of economic weights and $b = P^{-1}Ga$. The prediction of actual response is calculated using the incorrect index weights (*b* values) in conjunction with the true *P* and *G* matrices in the response equation, where the incorrect *b* values are calculated from the incorrect *P* and *G* matrices. The derivation of the response formula using *b* values from one set of parameters with another set of parameters follows from James (1982). In this paper simulations are used to investigate the consequences of assuming zero genetic correlations between FEC and production traits, which is common in the Merino industry, when a different set of true parameters exist in a population.

MATERIALS AND METHODS

The program used for predicting genetic gain (SELIND; Cunningham 1969) was modified by Hickson (1996) to allow the combination of incorrect *b* values with true *P* and *G* matrices for predicting response. For each prediction there were 8 traits in the breeding objective - a range of production traits plus FEC; and 4 selection criteria - hogget (16 month) clean fleece weight, fibre diameter and body weight plus FEC. A range of implied REVs was calculated to give a specified desired gain for FEC from 0 to 90% of total gain possible, using the incorrect parameters. This was done by specifying the gain in FEC and allowing the change in production traits to be optimised in accordance with their REVs (Brascamp 1984).

The effect of assuming different genetic correlations was assessed by the impact on aggregate economic merit of the production traits (production index), which was calculated from the response per trait in standard deviation units multiplied by the appropriately scaled REV. Also presented is the effect that changing the assumed genetic correlations had on gain in FEC. In all predictions the incorrect parameters were defined as zero genetic correlations between FEC and production traits. The true genetic correlations of production traits with FEC were those estimated by Eady (1996) for hogget and adult clean fleece weight (HCFW, ACFW), fibre diameter (HFD, AFD) and body weight (HBW, ABW) (Table 1). A mean of published estimates was used for reproductive rate (RR) (Piper 1987, Woolaston *et al.* 1991). Heritability for FEC was 0.25. Heritabilities and co-variances between production traits are from Semple *et al.* (1994). Phenotypic correlations were kept at zero for all predictions.

Table 1. Best available estimates of the genetic correlation of FEC with production traits, and relative economic values (REV) for production traits.

Trait	HCFW	ACFW	HFD	AFD	HBW	ABW	RR
FEC	0.08	0.08	-0.05	-0.05	-0.21	-0.21	-0.14
REV ($/ewe lifetime)	0.87	0.99	-4.56	-4.56	0.32	0.06	84.29

RESULTS

Predicted genetic gain assuming zero genetic correlations slightly under-estimated the actual response in the production index and over-estimated the predicted change in FEC (Figure 1). The amount by which response in the production index was under-estimated increased with increasing REV for FEC. For a 50% desired gain index, a commonly used option in Merino studs selecting for worm resistance, the under-estimate was 1.6%. The amount by which the response in FEC was over-estimated decreased as FEC REV increased. The predicted response in FEC over-estimated the actual response by 17.6% for a desired gain index of 50%. The ratio of the contribution of each objective trait to the overall index merit was the same over the range of REVs for FEC when the genetic correlations between FEC and production traits were zero (result not plotted). When the true parameters were used (with zero correlations to construct the selection index), the ratio of the contribution of RR with the other production traits changed, with RR making a substantially greater contribution (Figure 2). This was partly balanced by reductions in the relative contribution of hogget and adult CFW and FD, traits that were unfavourably correlated with FEC. The body weight traits, which were favourably correlated with FEC, increased in contribution with increasing REV for FEC.

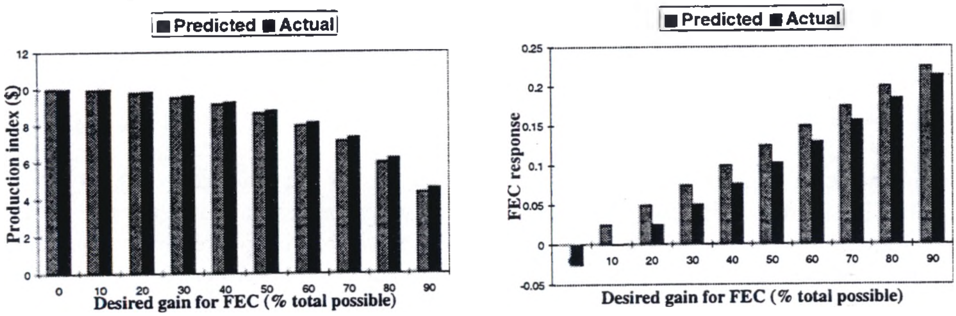

Figure 1. Predicted and actual response in production index and FEC, if assumed parameters are incorrect.

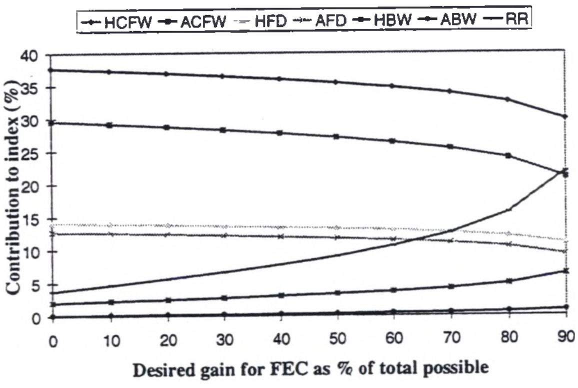

Figure 2. Relative contribution of each breeding objective trait to production merit when the genetic correlations between FEC and production traits are actually the best available estimates but with zero correlations used to construct the selection index.

DISCUSSION

The consequence of wrongly assuming covariances of zero to predict response appears, on first appraisal, to be relatively minor in terms of the effect on production traits (a slight under-estimate of response). However, upon closer examination of the contribution of individual objective traits to the index (Figure 2), it becomes obvious that the contribution of RR increases considerably as greater emphasis is placed on FEC. If there is danger in assuming a zero correlation in a Merino population where the true correlation is significantly different, it is to under-estimate substantially the changes that will occur in RR. The sensitivity in RR response comes about due to its low heritability and the fact that the genetic correlations between RR and production traits of high economic value (CFW and FD) are very low. When a moderately heritable and correlated trait, such as FEC, is introduced a greater selection differential can be achieved for RR. Combined with a high REV for RR, the result is that a much more substantial contribution is made by RR to the breeding objective. Unfortunately, it is difficult to obtain precise parameters for RR because of the time needed to collect records and the binary nature of the trait. However, more information on the genetic correlation between FEC and RR is needed to confidently predict the contribution of RR to the overall breeding objective, especially as emphasis on FEC increases.

The other point of interest from the results presented here is the amount by which predicted change in FEC is over-estimated if zero genetic correlations are assumed in a population where they are not appropriate. This is particularly relevant where sheep breeders are placing a relatively low emphasis on FEC, and given the favourable correlation between BW and FEC, may be exacerbated if the index does not include BW measures. For a desired gain in FEC of 30% predicted response over-estimates the change in FEC by a third and at a 20% desired gain, by close to a half. This occurs because the true co-variances create an overall relationship between FEC and production that is unfavourable, as indicated by the actual response when there is zero emphasis on FEC (Figure 1). If zero genetic correlations are incorrectly used, breeders may think they are making substantially more gain in worm resistance than would be happening in practice, especially if they are only placing a relatively low emphasis on FEC.

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