Chapter 9 General Conclusions

Livestock breeders across the world are striving to produce the "perfect" animal for their own environment and production system. Until recent times this effort focused primarily on increasing the level of production for traits of major economic importance. This orientation has shifted, to some degree, to include disease resistance and functional traits such as udder conformation, changes brought about by the erosion in effectiveness of disease control strategies and the increased physical demands placed on the animal by higher production.

In the Australian sheep industry anthelmintic resistance continues to push control strategies to their limits and fuels interest in alternate avenues of worm control. Some Merino breeders have responded to this situation by doing what they best understand - selecting livestock that are resistant to worm infection. *Nemesis*, a technology transfer project put in place to assist breeders incorporate worm resistance into their breeding program, is now working with a growing number of studs to meet this goal. This is the result of a forward-looking research effort by a number of individuals over the last 20 years and is an excellent example of sound quantitative genetic research being followed through to its practical extension in commercial animal breeding. The findings reported in this thesis provided a part of the information needed to allow Merino breeders to improve the disease resistance of their sheep.

Treatment of data was the first issue addressed in this thesis. FEC, the trait chosen to indicate worm resistance, was not normally distributed and required transformation for analysis. The most appropriate transformation for the data evaluated was a cube root. As selection outcomes were relatively robust to the type of transformation used, the cube root was adopted as the standard for all FEC analysis. Further adjustment of $FEC^{0.33}$ to standard deviation units was found necessary when genetic links were used to compare animals across years. A consistent presentation of FEC EBVs was developed so that information from different flocks and sire evaluation schemes could be easily interpreted.

Sources of genetic variation for parasite resistance were then identified so that breeders had a guide to the most effective avenue of incorporating resistance in their flocks. This was done by resistance testing all the Merino resource flocks across Australia where strain, bloodline and within-bloodline comparisons could be made. The outcome of this study was that there were only small and unpredictable differences between these Merino strains and bloodlines for parasite resistance. The major source of genetic variation was between-sires within-bloodlines, with heritability estimates for $FEC^{0.33}$ averaging 0.21±0.03 Based on this information the best avenue for improving resistance in a flock is to identify and use individual sires that are relatively resistant. The measurement of parasite resistance in all of the major resource flocks in Australia represented the first utilisation of these resources by the one national project and demonstrated the value of these flocks in allowing the rapid and effective evaluation of a new trait.

The genetic relationship between worm resistance and production traits was investigated by checking for a correlated response in Merino flocks selected for production, as well as by direct estimation from data provided by the resource flocks. There was no strong evidence of either a favourable or unfavourable genetic association between FEC and wool traits, with estimates small in value and varying in sign depending on age of fleece measurement. However, the standard errors associated with the estimates do not preclude some significant correlations (greater than 0.2 in magnitude) existing. There was evidence from the weaning weight selection lines that the correlation between FEC and body weight traits was favourable and this was supported by estimates for the genetic correlations between FEC and body weight that were generally negative in sign. A case may exist for varying the genetic correlations from zero and if so pooled estimates for the correlation of FEC with GFW, CFW, FD and BW would be in the order of 0.15, 0.10, -0.06 and -0.21. Sensitivity analysis showed the aggregate merit of production traits was influenced the most by the genetic correlation between FEC and fleece weight, followed by reproductive rate, then fibre diameter and least by the correlation between FEC and body weight. The consequences of incorrectly assuming zero genetic correlations were the most serious for the correlation between FEC and reproductive rate, and further estimates of this correlation would be useful.

The genetic parameters found in these studies are likely to be applicable over a range of environments, even as the effectiveness of drenching programs decline, as alternate strategies are likely to be employed to ameliorate the effects of infection. The major emphasis of future work should shift from parameter estimation, with the previously mentioned qualification for reproductive rate, to an assessment of alternate control strategies including the potential costs of breeding for resistance and the interaction between control strategies, host immunity and the epidemiology of the host-parasite system.

Various strategies for including FEC testing in a breeding program were evaluated using economic returns from discounted gene flow analyses. The outcome from this study was that including FEC in a testing program is cost effective given the REV for FEC is equivalent to, or greater than, that implied by a 30% desired gain for the trait. The optimal testing strategy for most studs is likely to be to reduce the number of rams being measured by testing for FEC at a second stage of selection, the accuracy of the FEC test being improved by a repeat measurement. Investment in testing of ewes can improve returns in the long term, but is expensive in the early years of selection before returns begin to be realised. This information demonstrates to breeders that there are benefits in closely examining the particular testing strategy they employ.

As stated in the conclusion to Chapter 7, the critical issue that is yet to be resolved is what the true REV for FEC is likely to be. This information is needed for a range of situations so that sheep breeders can have confidence that including helminth resistance in their breeding objective will improve the profitability of their wool producing enterprise and that of their ram buying clients.

Determining a REV for FEC will be a complex task and there may never be as precise an estimate as there is for fleece weight or fibre diameter. However, there are many approaches that can be used to gain some indication of the value of breeding for parasite resistance. Epidemiological models can be used to predict the change in drench requirements of a flock as it becomes more resistant through selection. The experimental flocks selected for parasite resistance can be examined for physiological and immunological changes that may impact on their productivity. Predictions can be made regarding the interaction of alternate parasite control strategies, such as vaccination and biological control, and the likely value that improving host resistance has in ensuring a sustainable approach to the management of disease.

This thesis provides a small number of answers to a complex but exciting area of research and there is much more to be done as scientific endeavour assists the industry to move towards a more balanced system of improving livestock production.

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