**NEMESIS - SYSTEMS FOR INCORPORATING RESISTANCE TO WORMS IN MERINO BREEDING PROGRAMS**

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**SUMMARY**

*Nemesis* is a national technology transfer project which aims to develop systems for incorporating resistance to worms in Merino breeding programs. The three year project commenced in July 1994 as a collaborative venture between CSIRO Division of Animal Production and the University of New England at Armidale and Agriculture WA in Katanning, with funding support from Australian wool growers through the International Wool Secretariat. The project was initiated because of encouraging research outcomes which demonstrated the potential to improve worm resistance through breeding and because of substantial pressure from the industry to utilise this technology. The methodology for breeding for worm resistance has been established on a number of studs in problem wool areas.

**Keywords:** Nemesis, worm resistance, technology transfer, Merino.

**INTRODUCTION**

Research into breeding for host resistance to internal parasites commenced in Australia in the late 1970s, prompted by evolution of widespread anthelmintic (benzimidazole) resistance in worms and recognition that there are large differences between individual sheep in their ability to withstand worm infection. The first goal was to determine if worm resistance in sheep is heritable. Would sires with a low faecal egg count (FEC) pass any of that advantage on to their offspring? Piper (1987) reported that the heritability of FEC (measured at 18 months of age in New England bred Merino sheep) was about 25% and this has been confirmed by numerous studies in a range of Merino bloodlines across Australia (Eady et al. 1996). Selection lines were established in 1977 and the sheep were bred for either high or low FEC after infection with *Haemonchus contortus* (Barber’s Pole worm), together with an unselected control line. Similar lines were established for resistance to *Trichostrongylus colubriformis* (Black Scour worm) in 1975 (Dineen and Windon 1980) and a mixture of worms after natural infection (at Hamilton in 1988, Cummins et al. 1991; at Boyup Brook in 1987, Karlsson et al. 1991). These flocks have demonstrated the feasibility of breeding for worm resistance and that the FEC of the resistant lines, when compared to unselected sheep, was significantly reduced. In the *H. contortus* lines FEC was halved over a 10 year period (Woolaston and Piper 1996). Further, weaners selected for resistance to one worm species also show considerable cross-resistance to other species and females maintain their resistance later in life as lambing ewes (Woolaston et al. 1990). Genetic variation for FEC in Merinos appears to be mainly within flock, that is individual sires vary greatly in their resistance but there are only small differences between flocks or strains (Eady et al. 1996).
In the early to mid 1980s many sheep producers were experiencing high levels of anthelmintic resistance to all drugs available for worm control. The Australian release of ivermectin in 1988 brought immediate relief to these sheep producers. However, with greater understanding of how anthelmintic resistance develops many producers realised that the new drug had a limited life-span. Ram breeders who became aware of high levels of anthelmintic resistance on their properties, and the properties of their ram buying clients, began to consider options for a sustainable approach to worm control. At this point the decision was made to put in place a national technology transfer project to assist ram breeders to incorporate worm resistance into their breeding programs.

NEMESIS IN DEVELOPMENT
Ideas for a technology transfer project were developed jointly by CSIRO, UNE and AgricWA. The project (un-named at that stage) was launched in July 1994 by advertising in the major rural press for ram breeders who wished to commence breeding for resistance and who required practical and technical assistance. In response to the advertisements the project was contacted by 80-90 ram breeders and there were over 150 general expressions of interest. From this initial response the base mailing list for the project newsletter was generated, to which over 500 names have now been added.

At the same time as the advertisements appeared, a group which included Department of Agriculture advisors, private veterinary and breeding consultants and researchers with an interest in sheep breeding and parasite control were sent extra information on the project as well as background on relevant research. This group took part in a series of technical workshops, conducted in the first six months of the project, in Armidale and Orange (NSW), Hamilton (VIC), Campbell Town (TAS) and Katanning (WA). The goal of these workshops was to increase general awareness and understanding of the research behind the project, as many of the participants were unfamiliar with the technology and would be the first point of contact for breeders wanting more information.

Late in 1994 the project was named Nemesis after some creative thought by the Armidale partners. The name has several associations, sounding a little like ‘nematode’ and being derived from the Greek meaning both to ‘graze’ and ‘disseminate’. The further association with Nemesis, the Greek goddess of ‘just retribution for over-confidence’ has inspired moderation in our claims for the project! Having an identifying name has been a useful way to describe and talk about the project in the media and among breeders and organisations.

NEMESIS IN ACTION
The resources of the project enabled 11 ram breeders, of the 80-90 who expressed interest, to become collaborators. They were selected to cover a range of enterprise sizes, backgrounds and geographical locations (Table 1). Each breeder was visited on-property and a measurement program for worm resistance was planned, taking into account time of lambing, shearing and most likely period of worm challenge. Resistance testing to date has been based on FEC of young sheep from 7-14 months of age. FEC has been measured after either natural or artificial challenge. Practical issues that have been encountered by breeders are summarised in Table 1.
At the outset of the project it was recognised that breeding for parasite resistance was applicable, not to the Merino industry as a whole, but to those regions where worm control is an important management concern. All of the original collaborators, with the exception of “Southrose” which is in a lower rainfall region, have now completed 2-3 years of testing of young sheep. Results from the studs have been presented by breeders at industry conferences and field days (Pocock et al. 1995) and in the Nemesis newsletter.

Table 1. Stud, infection type and specific issues of importance

<table>
<thead>
<tr>
<th>Stud</th>
<th>Type of Infection</th>
<th>Issue</th>
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<tbody>
<tr>
<td>“Nareen”</td>
<td>Western Districts, VIC. Artificial infection</td>
<td>A major concern was the effect worm challenge, either natural or artificial, would have on the welfare of the sheep. This was resolved by an experiment with weaner ewes to assess the impact of an artificial infection on liveweight. Results were published in Nemesis and by Kisielewicz et al. 1995.</td>
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<tr>
<td>“Merigan”</td>
<td>Southern Tablelands, NSW. Natural</td>
<td>Unpredictability of natural challenge demonstrated the need for regular monitoring. A phenotypic selection index was being used and the inclusion of FEC required economic weights to be calculated for production traits.</td>
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<tr>
<td>“Hazeldean”</td>
<td>Southern Tablelands, NSW. Artificial infection</td>
<td>An artificial challenge was used because of the unpredictable nature of worm challenge in this environment and the desire to keep the sheep worm-free during the harsh Monaro winter. This system appears to have worked well aided by the enthusiastic involvement of the local veterinary officer with the Rural Lands Protection Board. Involvement of local support staff has been actively encouraged.</td>
</tr>
<tr>
<td>“Nerstane”</td>
<td>New England, NSW. Artificial &amp; natural</td>
<td>The selection emphasis for FEC was initially 50% but this was felt to be too high and was dropped back to 25%.</td>
</tr>
<tr>
<td>“Miramoona”</td>
<td>New England, NSW. Artificial</td>
<td>Repeatability of FEC, measured twice in a six day period, was monitored on this property and proved to be low. The sheep were undergoing supplementation with grain during this time and although they had been on the supplement for a number of months there was a change in the type of grain fed about the time of the faecal sampling. This supports information on the effect of management changes (Kelly and Gray 1995).</td>
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<tr>
<td>“Billandri”</td>
<td>South Central, WA. Natural</td>
<td>Variation in rainfall at the break of the season meant that FECs needed to be monitored often to determine when counts were high enough to sample all sheep.</td>
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<td>“Blackford”</td>
<td>South East, SA. Natural</td>
<td>Unexpected rankings of some sires with previous FEC test results indicated the need to continue building up a bank of information on a range of sires in different environments.</td>
</tr>
<tr>
<td>“Panlatinga”</td>
<td>South East, SA. Natural</td>
<td>Dagginess is an additional problem perceived to be related to worm infection. To provide some information between dag score and FEC the sheep were scored at time of faecal sampling. Dag score and FEC relationship (Pocock et al. 1995) was not clear cut. This result highlighted the need to clarify this relationship between FEC and dagginess.</td>
</tr>
<tr>
<td>“Southrose”</td>
<td>South East, SA. Artificial</td>
<td>Impact of worms in this environment is not as large as in other regions where studs were located and the measurement program ceased after the first year, demonstrating how assessment of economic value for resistance is dependent on environment.</td>
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<tr>
<td>“Aramis”</td>
<td>South East, SA. Natural</td>
<td>A small group of ewes and rams were counted and FEC EBVs returned for inclusion in the current MerinoTech evaluation. Feedback on reporting procedures highlighted the need for a standard protocol so that all relevant information is returned to breeders.</td>
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<tr>
<td>“Gracemere”</td>
<td>East Gippsland, VIC. Natural</td>
<td>Ovine lymphocyte antigen typing was done on some sires which had FEC breeding values estimated. It appeared that the ram with the most “resistant” OLA type had a very high FEC EBV, indicating its relative susceptibility to worms. Additional FECs were done in a different lab which confirmed the EBV for that ram. This result by itself is equivocal but in the context of the OLA/FEC studies that have been completed, it suggests that OLA type is not a useful indicator trait for worm resistance (Nemesis Newsletter No.7, May 1996).</td>
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The collaborating studs have formed a focus of interest in each of the districts and have hosted and participated in workshops for other ram breeders wanting to commence selection for worm resistance. A number of the studs have also held field days and special interest days to explain to their clients how worm resistance is being included in their breeding objective.

CONCURRENT ACTIVITIES
A number of support activities have been undertaken during the project which include the evaluation of alternate egg counting techniques, an assessment of the impact of management changes on the repeatability of FEC measurement (Kelly and Gray 1995), and a number of studies examining the effectiveness of alternate indicators of resistance such as OLA type (Nemesis Newsletter No.7, May 1996), eosinophil count (Woolaston et al. 1995) and worm antigen levels in both the blood and faeces. FEC Breeding Values have also been estimated in a number of Central Test Sire Evaluations to assist breeders to identify resistant rams that they may wish to use in an AI program. These activities have been an integral part of the project as there has been a need to respond to particular issues that have arisen in the field. It has also been necessary to implement strategic research which will improve our level of knowledge and also the confidence of the end users of the technology.

CONCLUSION
The Nemesis project will ensure that, as far as possible, the methodology developed will stand on its own and become an integral part of breeding programs of studs in worm-susceptible districts. An independent evaluation of Nemesis is currently underway and it is proposed that the results of this study, as well as a review of the outcomes of on-farm application and research, will be presented at a summary workshop. This will allow an assessment of the methodology used for Nemesis and its suitability for application in other technology transfer projects.

REFERENCES