RESILIENCE TO HAEMONCHUS CONTORUTUS INFECTION IN LAMBS CROSSBRED BETWEEN MERINO STRAINS AND BLOODLINES

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SUMMARY
A total of 340 Merino ewe lambs were infected with a standardised dose of infective larvae of the bloodsucking abomasal nematode Haemonchus contortus. These lambs were from a larger experiment designed to examine the effects on production of crossbreeding among Merino strains and bloodlines. Around 30% of the lambs were purebred with parents of the same bloodline, while the remainder were crossbred with parents of different bloodlines and/or strains. Liveweight gain (LWG) and blood packed cell volume (PCV) were measured before and after the 5 week infection period and worm burden was estimated from faecal egg output. There was no significant effect of crossbreeding on PCV decline or worm burden (resistance), or on LWG at any time before or after infection. During infection, resilience (LWG adjusted for initial bodyweight, worm burden and PCV decline) was 46% greater in crossbreds than in purebreds. It is concluded that this type of crossbreeding has caused increased resilience to infection.

INTRODUCTION
Breeding for increased production in domestic animals by selecting for disease resistance is important in some species, particularly poultry (Gavora and Spencer 1983). In sheep, many nematode parasites have developed resistance to anthelmintic drugs used for their control and the potential for genetic improvement of host resistance to these infections is clear (Dineen, 1984). The response to parasitic infection has been classified into the ability of the host to "control" the parasite burden by reducing establishment or survival of parasites and the ability to "live with" the parasite burden by maintaining production while infected (Gavora 1984). Albers et al. (1984) used the expressions "resistance" and "resilience" to describe these same concepts in sheep infected with Haemonchus contortus. In this paper, resilience to H. contortus infection is described in crossbred and purebred populations of Merino sheep of various strains and bloodlines.
Resistance and Resilience. Genetic variation in resistance to parasitic infection in many host species has been well described (Wakelin 1985). Resistance to nematode infections is generally measured as the level of worm egg output (eggs per gram of faeces:epg) measured at a fixed interval after infection. Alternatively worm burdens have been measured directly after necropsy, but in all cases resistance has the same general sense of "level of worm burden". Resilience was defined by Albers et al. (1984) as the ability of animals to maintain a relatively undepressed level of production (as kilograms liveweight) while infected. The measurement of resilience as an independent trait is difficult as it can only be made by comparing animals with equal worm burdens. In practice this is not possible because even following a standard infective dose of larvae the level of worm burden will be variable between hosts. Equalisation of worm burden can be carried out statistically (Albers et al. 1984) by means of regression: liveweight gain during infection being adjusted for epg. This procedure has been adopted in this paper although it will be shown also that it was unnecessary, as equal levels of worm burden (resistance) resulted in both purebred and crossbred populations.

Genetic Variation in Resistance and Resilience. In sheep, between breed variation in resistance to H. contortus has been described in several studies (Preston and Allonby 1979; Piper et al. 1978; Courtney et al. 1985). Variation within populations has been described by LeJambre et al. (1978) and Albers et al. (1984), who estimated the heritability of resistance to be 0.35 ± 0.15 and 0.29 ± 0.12 respectively. Further it is likely that in addition to polygenic variation, single genes for resistance occur (Whitlock and Madsen 1957; Albers et al. 1984).

 Genetic variation in resilience has received little attention mainly because of the difficulty of measuring the trait. Albers et al. (1984) determined that resistance and resilience to H. contortus were to some degree independent of each other (genetic correlation of 0.56 ± 0.23). The implied advantage of selection for resilience is that hosts would retain a substantial parasite burden and thus exert less selection pressure on the parasite to adapt to host resistance mechanisms than would hosts selected for resistance alone. The epidemiological consequences of selection for resistance and resilience have been discussed by Albers and Gray (1986).

Effect of Crossbreeding on Resistance and Resilience. Piper et al. (1978) described reduced epg levels in crossbred Merino x Corriedale lambs when compared with their purebred counterparts. Otherwise little work has been done in this area and it would be of interest to the Australian Merino industry to increase disease resistance and improve productivity by crossbreeding both between Merino strains and within strains (between bloodlines). The present study is a small part of a major study being undertaken by the New South Wales Department of Agriculture to quantify the benefits of crossbreeding.
EXPERIMENTAL DESIGN

A complete diallel crossbreeding experiment was established in 1984 involving 8 Merino bloodlines from the following strains: Fine (2), Medium Non-Peppin (2), Medium Peppin (3) and Strong (1). A detailed description of the base flocks has been given by Atkins and McGuirk (1976). Three rams from each bloodline were each mated to 12-15 ewes of the same bloodline and 25-30 ewes of the remaining seven bloodlines. This number of ewes per mating group resulted in approximately 30% of all lambs born being purebred with parents from the same bloodline and the remainder being crossbred with parents of different bloodlines and/or strains. All possible mating combinations within the 8 x 8 diallel were carried out.

Three hundred and forty 7 month old ewe lambs were separated at weaning from their sibling rams and grazed together. All lambs were drenched with a broad spectrum anthelmintic (oxfendazole 5 mg/kg) and set-stocked on dry (unirrigated) pasture. Two weeks later the animals were weighed, bled for estimation of packed red blood cell volume (PCV) and infected intraruminally with 10,000 infective H. contortus larvae (McMaster strain). The lambs were observed regularly but no further procedures were carried out until 5 weeks after infection when the lambs were weighed, bled for PCV determination and a faecal sample collected for estimation of worm egg output (epg). At this point the infection was terminated by a combined narrow spectrum (closantel 7.5 mg/kg) and broad spectrum (albendazole 3.8 mg/kg) anthelmintic. The lambs were returned to dry pasture for one week before being moved to irrigated pasture. No uninfected controls were included in the experiment, in contrast to the experiments of Albers et al. (1984).

Least squares analysis allowed adjustments to be made for the fixed effects of "age of dam", "birth and rearing type", "age of lamb", "bloodline of sire" and "bloodline of dam". The specific comparison for the purebred vs crossbred interaction was part of the "bloodline of sire" x "bloodline of dam" interaction. All models accounted for the random effects of sire within each bloodline.

RESULTS

For all animals the average decline in PCV was 11.8% ± 0.7% and the average worm egg output was 10,340 ± 748 epg. Daily growth rates of the crossbred lambs were on average 47% higher than purebred lambs during infection. After adjusting daily growth rates while infected for initial liveweight, changes in PCV and epg levels, resilience was calculated (Table 1).
Table 1: The effect of crossbreeding on various parameters of growth and response to infection in lambs infected with *H. contortus*. (Group means are "least squares" estimates).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Purebreds</th>
<th>Crossbreds</th>
<th>Difference</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (SE)</td>
<td>Mean (SE)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Daily Liveweight Gain (g/d)*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Birth - weaning (5 months)</td>
<td>165 (4.8)</td>
<td>164 (4.2)</td>
<td>0%</td>
<td>NS</td>
</tr>
<tr>
<td>Weaning - pre-infection (6 weeks)</td>
<td>47 (7.1)</td>
<td>51 (6.2)</td>
<td>+9%</td>
<td>NS</td>
</tr>
<tr>
<td>Infection period (5 weeks)</td>
<td>34 (5.6)</td>
<td>50 (4.5)</td>
<td>+47%</td>
<td>P&lt;0.01</td>
</tr>
<tr>
<td>Post infection (10 weeks)</td>
<td>33 (4.2)</td>
<td>31 (3.7)</td>
<td>-5%</td>
<td>NS</td>
</tr>
<tr>
<td>Decline in PCV (packed cell volume) (%)</td>
<td>12.4 (0.46)</td>
<td>11.5 (0.36)</td>
<td>-7%</td>
<td>NS</td>
</tr>
<tr>
<td>Eggs per gram of faeces (square root of epg)</td>
<td>107.5 (5.0)</td>
<td>104.0 (4.0)</td>
<td>+1%</td>
<td>NS</td>
</tr>
<tr>
<td>Resilience*</td>
<td>34.9 (5.3)</td>
<td>50.9 (4.1)</td>
<td>+46%</td>
<td>P&lt;0.01</td>
</tr>
</tbody>
</table>

* All average daily gains were adjusted for fixed effects (age of dam, birth and rearing type, age of lamb, bloodline of sire and bloodline of dam).

+ Resilience is average daily gain during infection adjusted for differences in initial bodyweight at day 0 of infection, decline in PCV and epg.

DISCUSSION

It is clear that crossbreeding in this flock has affected LWG during infection but not the worm burden as measured by the level of worm egg output or the consequent anaemia of the host. Crossbreeding has increased resilience but not resistance to infection.

Three years of experiment are planned in order to fully assess the effect of crossbreeding in these flocks and therefore these results are of a very preliminary nature. The effect of crossbreeding on LWG during infection is so pronounced that more intensive studies are planned to explain the results. Only two liveweight measurements were made: at the beginning and end of infection, and clearly it would be of interest to determine at what stage of infection the differences in LWG occur. From our own experiments in purebred Merinos (Albers and Gray, unpublished) the period of maximum growth depression in a five week infection is between three and five weeks. Additional weighings in the crossbreeding experiments may confirm this observation.

Mechanisms of Resilience. No conclusion can be made as to the mechanisms underlying resilience in this experiment. Increased growth as a result of crossbreeding is well documented (Nitter 1978) and it may be that this effect...
is due to increased voluntary food intake (VFI). Nematode parasite infections have been shown to reduce VFI in sheep in some circumstances (Holmes 1985) and, in general, anorexia is a common result of parasitism (Symons 1985). Assuming that the results obtained here are due to decreased anorexia in crossbred lambs and if the effect is most marked in the last two weeks of infection, then the difference in VFI between the two groups can be calculated, by the method of Oddy (1978), to be between 20% and 30%. Measuring VFI in grazing animals is difficult but can be facilitated by the use of slow release capsules containing chromic oxide (Ellis et al. 1982). Anorexia may not be expressed at all levels of nutrition as demonstrated by Abbott et al. (1985), who showed that LWG was depressed in sheep infected with H. contortus on a low protein diet but not in those on a high protein diet. This type of resilience may only occur, therefore, if pasture is of poor quality. On the other hand it may be in just such circumstances that resilience is of use to the farmer.

CONCLUSIONS

A significant difference in LWG between crossbred and purebred Merino sheep infected with H. contortus has been observed. While these findings are of a preliminary nature and it is premature to make any conclusions as to their practical significance, the results are sufficiently clear to provide a basis on which studies of the mechanisms of resilience to H. contortus or other parasitic infections in other ruminant species can be undertaken.

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