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Genetic variation in resistance or tolerance to internal nematode parasites in strains of sheep at Rotomahana

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ABSTRACT

Gastrointestinal nematode parasitism is a major concern for animal health and productivity. Studies at Rotomahana Research Station are evaluating the potential of genetic selection of sheep with increased resistance and/or tolerance to parasitism.

Progeny testing of 35 sires in 1984 and 20 of these again during 1985 to investigate strain and sire variation, as well as repeatability in faecal egg counts (FEC), revealed an average heritability estimate of 0.34±0.19 in ewe lambs. Strain and sire rankings were consistent across years and across sexes in 1985 when both wether and ewe lambs were faecal sampled.

Notably, the Ruakura High Fertility Romney strain had the highest FEC and above average live-weight gains yet below average dag score of the 5 strains compared. These results suggest that this line may be tolerant rather than resistant to nematode parasite infection.

Moderate heritabilities for FEC suggest that selection responses could be achieved with Romney sheep. Neither live-weight gain nor dag score was favourably correlated with FEC.

Keywords Resistance; nematode; sheep; strains; breeds; parasites; heritability; correlations

INTRODUCTION

Studies at the Rotomahana Research Station established that there was genetic variation between and within strains or breeds of sheep in incidence of dags (Meyer *et al.,* 1983). Among progeny of 6 Romney strains, daughters of Ruakura High Fertility strain rams had the lowest incidence of dags (33%) with little variation among the other 5 Romney strains, Border Leicester x Romney or Coopworth x Romney (52 to 56%). The mean heritability of dag score was 0.31, indicating that selection would be effective in reducing the incidence of dags and their associated costs to farmers. Daggy sheep are often regarded as an indication of heavy parasite burdens and time for a drench (Meyer *et al.,* 1983). Subsequent studies at Rotomahana have investigated the relationship between dagginess and internal parasite worm burdens assessed through both faecal egg counts (FEC) and autopsy procedures. These trials have also provided evidence for genetic variation in faecal egg counts (FEC) and relationships with other production traits (e.g. live-weight gain).

RESULTS AND DISCUSSION

1983 Trial

A trial in 1983 measured FEC on 140 Strain trial ewe lambs (born in 1982) 5 times between 1 February and 20 August. Egg counts showed considerable variation over this period with a peak of about 800 eggs/g (epg) in late February—early March. At none of the measurement times was there any significant variation among breeds or strains for FEC, nor was there any apparent relationship between FEC and dag score. At the peak in February the Ruakura High Fertility lambs had the highest FEC, although this strain had the lowest incidence of dags.

In addition in 1983, actual worm burdens were measured in 100 wether lambs which were half sibs to the ewe lambs sampled for FEC. The wether lambs were serially slaughtered at the 5 times FEC sampling occurred in ewe lambs. By pooling over slaughter groups a significant positive association was found between *Ostertagia* and *Trichostrongylus* worm burdens and FEC taken prior to slaughter, but no significant variation was found in mean worm count among breeds or strains. An important feature of this 1983 trial was that lambs were drenched regularly. Subsequent trials in 1984 and 1985 concentrated on faecal sampling in early and late autumn with minimal drenching to allow any variation for animal resistance to parasites or tolerance to infection to be expressed.

1984 and 1985 Trials

In 1984, 232 Strain trial ewe lambs (born in 1983 from 35 sires (5 sires from each of 7 strains)) were faecal sampled on 14/3/84 and 197 lambs were resampled on 2/5/84. Lambs were drenched on 30/12/83, 15/3/84 and 3/5/84. A sample of about 30 sheep were monitored for FEC until the mean was approximately 1500 epg at which time all lambs in the trial were faecal sampled. In 1984 the 7 strains included 5 Romney strains and Coopworth x Romney and Border Leicester x Romney crosses.

From the 35 sires represented in the 1984 trial, 20 were repeat progeny tested to produce lambs in 1984 which were faecal sampled in 1985. These 20 sires represented 5 strains (4 sires/strain) of the 7 strains tested the previous year. One Romney strain and the Border Leicester x Romney were omitted. A total of 131 ewe lambs and 132 wether lambs were allocated to the 1985 trial, on average 6.5 lambs of each sex from each sire. Lambs sampled were restricted to those born in a 14-day lambing period to minimise age and seasonal effects on parasite challenge. The lambs were drenched at docking (mid-September 1985) and then again after the first faecal sampling (22/1/85) and the second faecal sampling (12/4/85). Wether lambs were sold after the second faecal sampling and ewe hoggets faecal sampled for a third time at approximately 1 year of age (21/10/85). Live weights and visual dag scores (range 0 to 4) were recorded at each faecal sampling date in 1984 and at the second and third sampling dates in 1985.

Culturing of faecal samples bulked for each strain in both 1984 and 1985 revealed no significant variation among strains in distribution of worm genera. However, between years and between sampling times within years, there was variation in the predominance of the different genera, with *Trichostrongylus* and *Ostertagia* most prevalent (Table 1). Faecal egg counts are presented separately for *Nematodirus* and total of all other worm species (Total epg) (Table 2).

Strain Variation

Initially least squares mixed-model analyses were undertaken for each sampling time separately with strain, birth-rearing rank, sex (1985 only) and birthdate as fixed effects and sires nested within strains as a random effect. With few exceptions birth-rearing rank and birthdate did not significantly affect FEC. Overall means and residual standard deviations at each

TABLE 1 Distribution of parasite genera (%) at 4 different faecal sampling times.

Parasite genera	14/3/84	2/5/84	22/1/85	12/4/85
Cooperia	5	14	20	1
Haemonchus	3	14	1	-
Ostertagia	6	40	46	66
Trichostrongylus	64	23	20	24
Chab/Oeo	22	9	13	9

sampling time are shown in Table 2 for ewe lambs. The desired mean of about 1500 epg was met for both samplings in 1984 and the first sampling in 1985. The second sampling in 1985 was delayed and the faecal egg counts rose rapidly over this perod resulting in a mean of 2583 epg in ewe lambs. Means for wether lambs are not shown in Table 2 but apart from higher total epg on 12/4/85 (3120) all other means were similar in both sexes. Wether lambs were not weighed or scored for dags at the second sampling in 1985. The average FEC was much lower at the sampling in October in 1985 (136), but the ewe lambs had been regularly drenched over the April—October period.

In all analyses on a within sampling date and within year basis, strains were not significantly different for any of the faecal traits, live-weight gains or dag score. However, ranking of strains was quite consistent between sampling times within years, across years and between sexes in 1985. Both strain x year and strain x sex interactions were non-significant. Strain means are shown in Table 3 for FEC, live-weight gain and dag score from an analysis including both the 1984 and 1985 ewe lambs. Strain differences were now found for FEC at the first ($P<0.10$) and second ($P<0.05$) sampling and dag score ($P<0.10$), but not for live-weight gains. Consistent with the 1983 results the Ruakura High Fertility Romneys (strain C) had high

TABLE 2 Overall means and residual standard deviations (SD) for faecal egg counts (epg), consistency score of the faecal sample (1-5), live weight at sampling (kg), and dag score (0-4) for ewe lambs.

Trait	14/3/84 Mean	SD	2/5/84 Mean	SD	22/1/85 Mean	SD	12/4/85 Mean	SD	21/10/85 Mean	SD
Total epg*	1694	1021	1396	882	1490	1140	2583	1950	136	288
Nematodirus epg	172	200	67	123	304	347	106	207	2	14
Consistency score	3.1	0.5	3.2	0.6	3.0	0.7	3.4	0.9	3.1	0.6
Live weight	26.3	3.4	30.3	3.6	20.5	3.2	27.6	3.8	45.2	4.9
Dag Score	1.8	1.2	3.2	1.1	-	-	2.3	1.1	2.0	1.2

*Excluding *Nematodirus* egg count.

TABLE 3 Strain means for faecal egg counts (log + 1 of epg,) live-weight gain (kg), and dag score (0-4 score) for ewe lambs sampled in 1984 and 1985.

Strain	First Sampling			Second sampling			
	No.	FEC	Gain	No.	FEC	Gain	Dag Score
Romney—A	47	6.9	9.5	40	7.2	5.0	3.1
B	58	7.2	10.0	51	7.2	5.4	2.6
C	62	7.3	10.4	52	7.3	5.4	2.3
D	58	7.1	10.3	49	7.4	5.0	2.8
E	28	6.8	10.0	23	6.7	5.5	2.8
Coopworth x Romney	73	7.1	10.6	63	7.3	5.4	3.0
Border Leicester x Romney	40	6.9	10.1	36	7.5	6.2	2.9
SED		0.2	0.7		0.3	0.5	0.4

FEC, above average live-weight gain, but the lowest incidence of dags. These results suggest that this line is tolerant rather than resistant to parasitic worm burdens. Correlating strain means there was a positive association between FEC and live-weight gain, no association of FEC with dag score and a negative association of dag score with live-weight gain.

Heritabilities and Correlations

Paternal half-sib heritabilities estimated separately for ewe and wether progeny are shown in Table 4. It should be noted that the lambs faecal-sampled in 1985 were sired by a sub-sample (20) of the 35 sires used to generate the lambs faecal sampled in 1984. This procedure was followed to permit the repeatability of sire progeny tests for faecal sampling traits to be evaluated. Both sire x year and sire x sex (1985) interactions were non-significant for all faecal traits shown in Table 4. It has been found that it is possible to consistently rank sire groups across sampling times within years, across years and across sexes for FEC.

The heritabilities for ewe lambs (Table 4) included the 1984 and 1985 data. They were derived from restricted maximum likelihood estimates of sire and error variance components (Patterson and Thompson, 1971), using all 35 sires and allowing for the repeat mating of the 20 sires. The heritabilities for wether lambs were derived from variance components estimated using Method 3 of Henderson (1953) based on just the 20 sire groups represented in the 1985 data. For all faecal egg counts, the (log + 1) transformation was used to normalise the error structure, but some skewness of the distribution still persisted.

Total FEC are moderately heritable (0.34), for ewe lambs and these results are consistent with similar estimates (0.29) reported by Piper *et al.* (1978) based on natural pasture worm infections, and by Albers *et al.* (1984) based on artificial infection with *Haemonchus contortus.* Inheritance of natural internal parasite infections has also been investigated in New Zealand at the Woodlands Research Station (McEwen, Mason and Clarke, personal communication). Their paternal half-sib heritability for total epg estimate based on measuring ram progeny over a 6-week post-weaning period was 0.14±0.07. This is similar to the comparable estimate based on wether lambs in this study of 0.08±0.24. The heritabilities for FEC in Table 4 (Total and *Nematodirus* epg) are higher for ewe than wether progeny. This finding needs to be investigated further with larger samples of male and female progeny. Based on the size of present standard errors, male and female estimates are not significantly different.

TABLE 4 Paternal half-sib heritability estimates ± standard errors.

	Sampling 1	Sampling 2
Ewe lambs (1984+85)		
Total epg (log + 1)	0.33±0.18	0.34±0.20
Nematodirus epg (log + 1)	0.50±0.22	0.65±0.25
Live-weight gain	0.36±0.19	0.10±0.13
Dag Score	-	0.50±0.22
Wether lambs (1985)		
Total epg (log + 1)	0.08±0.24	n.e.
Nematodirus epg (log + 1)	0.27±0.28	0.32±0.34

ı.e. Not estimable—negative sire variance components.

Selection for high and low responsiveness to vaccination with irradiated *Trichostrongylus colubriformis* has been reported by Windon and Dineen (1984). The paternal half-sib heritability estimate for FEC in the F1 and F2 generations was 0.41±0.19. The realised heritability, estimated from the divergence between the high and low lines pooled over both ram and ewe progeny, was 0.39±0.27. Realised heritabilities for males and female progeny separately were not significantly different.

The consistency score of the faeces was negatively correlated with FEC (i.e. more liquid faecal samples have lower egg counts). FEC was adjusted for consistency score by including it in the statistical model as a covariate. This had no appreciable effect on the heritability or correlation estimates.

In contrast to the positive correlation between FEC and live-weight gain among strains, the phenotypic correlation between FEC and gain prior to faecal sampling among animals within strains was slightly negative (-0.06) for both sampling 1 and 2. Genetic correlations were not consistent and were -0.43 for gain up to sampling 1 and 0.49 for gain from sampling 1 to sampling 2. Albers *et al.* (1984) reported that the genetic correlation between FEC and live-weight gain of uninfected lambs was -0.02±0.35 but when infection was introduced was -0.76±0.32. Correlated responses to selection reported by Windon and Dineen (1984) indicated that selection for high responsiveness (i.e. low FEC) *v* low responsiveness to vaccination with *Trichostongylus* was not associated with any significant differences between lines in wool growth or live-weight gain. However, at 7 weeks of age high responder rams were significantly heavier than low responder rams, but this effect was not found in females.

The phenotypic and genetic correlations between FEC and dag score were both negative (-0.18 and -0.7, respectively).

These results suggest that selection for increased live-weight gain will have little or no effect on FEC, but that selection for low dag incidence may actually increase FEC.

Future Work

In the 1985 mating at Rotomahana 3 Romney rams with highest FEC and 3 Romney rams with the lowest FEC based on progeny test results were mated to unrelated Romney ewes. This procedure will continue in 1986 and possibly subsequent years. It is hoped to generate 2 lines of sheep with genetically based differ ences in FEC. By using indoor direct challenge experiments at Ruakura progeny of these lines will be used to investigate physiological and immunological mechanisms involved in resistance or tolerance to faecal worm burdens.

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REFERENCES

Albers G.A.A.; Burgess S.E.; Adams D.B.; Barker J.S.F.; Le-Jambre L.F.; Piper L.R. 1984. Breeding *Haemonchus contortus* resistant sheep—problems and prospects. In *Immunogenetic approaches to the control of endoparasites with special reference to parasites of sheep.* Eds J.K. Dineen, P.M. Outteridge, Division of Animal Health, CSIRO, Australia. pp. 41-52.

Henderson C.R. 1953. Estimation of variance and covariance components. *Biometrics* **9:** 226-252.

Meyer H.H.; Harvey T.G.; Smeaton J.E. 1983. Genetic variation in incidence of daggy sheep—an indicator of genetic resistance to parasites? *Proceedings of the New Zealand Society of Animal Production* **43:** 87-89.

Patterson H.D.; Thompson R. 1971. Recovery of inter-block information when block sizes are unequal. *Biometrika* **58:** 545-554.

Piper L.R.; Le Jambre L.F.; Southcott W.H.; Ch'ang T.S. 1978. Natural worm burdens in Dorset Horn, Merino and Corriedale weaners and their crosses. *Proceedings of the Australian Society of Animal Production* **12:** 276.

Windon R.G.; Dineen J.K. 1984. Parasitological and immunological competence of lambs selected for high and low responsiveness to vaccination with irradiated *Trichostrongylus colubriformis.* In *Immuno genetics approaches to the control of endoparasites with special reference to parasites of sheep.* Eds J.K. Dineen, P.M. Outteridge, Division of Animal Health, CSIRO, Australia. pp. 13-29.