EXPLORING THE RELATIONSHIP BETWEEN LIVEWEIGHT CHANGE AND INTERNAL PARASITE BURDENS IN YOUNG MERINO SHEEP

S.J. Eady

CSIRO Livestock Industries, Locked Bag 1, Armidale NSW 2350, Australia

INTRODUCTION

There have been no reports of improved production in sheep selected (within breed) for worm resistance when they are under similar worm challenge to unselected sheep. In some instances, it appears that the productivity of genetically resistant sheep is compromised by selection for worm resistance (Morris *et al.,* 2000). Why do we not see the expected advantage (Sykes, 1994) in resistant sheep of having a lower worm burden? This experiment examines the relationship between liveweight gain and faecal egg count at regular intervals in young sheep over the course of 10 months in two flocks bred for resistance to internal parasites.

MATERIALS AND METHODS

Merino sheep, progeny of sires from random-bred control and worm resistant lines of two flocks selected, respectively, for resistance to *Haemonchus contortus* after artificial challenge (Haemonchus flock, Woolaston and Piper, 1996) and for resistance to natural infection (Rylington Park flock, Karlsson *et al.,* 1995) were used in this experiment. The 325 sheep were offspring of 7 and 3 sires, respectively, from the resistant and control Haemonchus flock, and 5 each from the resistant and control Rylington Park flock, averaging 16 sheep per sire (range 11-21). Rylington Park sheep were produced by artificial insemination while the Haemonchus flock was naturally mated for a 4 week period. Lambs were born Sep-Oct 2000, weaned in Feb 2001, and grazed together for the experiment (13 Feb to 4 Dec 2001) during which measurements of faecal egg count (FEC, eggs/gram) and liveweight gain (LWG, g/day) were made every 6 weeks. All sheep were treated once with anthelmintic (5 ml moxydectin) on the 22 Feb 2001 when mean FEC reached 1403 epg. FEC (cube root transformed, $FEC^{0.33}$) and LWG were analysed by ANOVA (Minitab) fitting sire within line as a random effect and fixed effects of line, sex, rearing rank, and counter for FEC. Day of birth was fitted as a covariate. First order interactions of all effects were fitted. Non-significant effects were dropped from final models. A partial correlation coefficient between FEC and LWG was calculated by correlating the residuals for the two traits after adjusting for the effect of other significant factors. FEC traits were FEC at the beginning of each 6 week period (1^{st} FEC), FEC at the end of each period (2^{nd} FEC), and the mean of the two FEC. Within and between-line correlations were tested for significant difference by fitting FEC residuals as a covariate in the model for LWG, which included the line x FEC residual interaction.

RESULTS AND DISCUSSION

Liveweight of the resistant lines was similar to their control throughout the experiment. Initial and final liveweight are given in Table 1. LWG, be it overall for the experiment or individual measures every 6 weeks, was similar for control and resistant lines. The only exception to this was LWG in the last 6 week period where the Haemonchus resistant line lost significantly ($P<0.05$) less weight than the control line (-19 versus -40 g/day, respectively). Mortality in the Rylington Park lines was similar (4%), while fewer sheep in the Haemonchus resistant line died (0% versus 7%, P<0.01). Although liveweight at weaning was similar for both flocks, differences in liveweight and LWG appeared by the end of the experiment in favour of the Rylington Park flock (Table 1). In the first 6 week period FEC differed significantly for the Haemonchus lines in favour of the resistant line (Table 1). For the next 3 periods resistant lines from both flocks were not significantly different from their control, while for the last 4 periods the Rylington Park resistant line had significantly lower FEC than the control line. Differences between the Haemonchus lines were significant in 2 of the last 4 periods.

Table 1. Liveweight (kg), liveweight gain (g/day) and faecal egg count (eggs/gram$^{0.33}$) of sheep from two flocks selected for resistance to internal parasites. Standard errors are given in parenthesis

	Rylington Park		Haemonchus	
	Control	Resistant	Control	Resistant
		Liveweight		
13 Feb	19.4 (0.73)	20.5 (0.64)	19.7 (0.74)	20.2 (0.69)
4 Dec	32.0 (0.97)	33.6 (0.86)	30.4 (1.00)	30.8 (0.92)
Liveweight gain	12.6 (0.78)	13.1 (0.69)	10.6 (0.80)	10.5 (0.74)
		Liveweight gain		
13 Feb to 28 Mar	65 (7.7)a	65 (6.8)a	51 (7.9)b	52 (7.4)b
28 Mar to 9 May	48 (4.2)	46 (4.1)	39 (4.7)	40 (3.2)
9 May to 20 Jun	94 (5.8)	79 (5.7)	84 (6.4)	81 (4.3)
20 Jun to 7 Aug	6 (10.8)	13 (9.6)	15 (11.1)	6 (10.3)
7 Aug to 18 Sep	-17 (8.5)	1 (7.5)	-26 (8.7)	-16 (8.1)
18 Sep to 29 Oct	92 (4.8)	93 (4.7)	89 (5.5)	85 (3.6)
29 Oct to 4 Dec	-20 (14.1)a	-26 (16.9)a	-40 (7.2)b	-19 (5.0)a
		Faecal egg count		
13 Feb	9.37 (0.29)a	9.75 (0.29)a	12.00 (0.32)c	10.95 (0.22)b
28 Mar	1.46 (0.26)	1.09 (0.25)	1.01 (0.29)	0.89 (0.19)
9 May	7.66 (0.82)	6.70 (0.72)	8.49 (0.84)	7.34 (0.78)
20 Jun	9.00 (0.35)	7.69 (0.35)	10.57 (0.39)	9.28 (0.27)
7 Aug	7.00 (0.45)b	4.11 (0.45)a	9.30 (0.51)c	7.86 (0.35)bc
18 Sep	6.88 (0.51)b	3.80 (0.52)a	9.46 (0.58)c	7.69 (0.42)b
29 Oct	6.47 (0.54)b	4.25 (0.54)a	8.65 (0.59)c	7.00 (0.42)bc
4 Dec	7.70 (0.52)bc	4.49 (0.53)a	9.48 (0.57)c	6.23 (0.41)ab

[a] Means with differing superscripts differ significantly (P<0.05).

The partial correlation coefficients between liveweight gain and various FEC traits are given in Table 2. When significantly different from zero, the within-line correlations are also given. Early in the experiment (28 Mar to 9 May) there was a significant negative correlation (-0.14, P<0.05) between 2nd FEC and LWG, and mean FEC and LWG (-0.15, P<0.01). Later in the experiment (from 7 Aug onwards) there was a consistently significant negative correlation between LWG and all FEC traits. On one occasion (7 Aug to 18 Sep) the correlation between LWG and 2nd FEC was significantly different between lines, with the correlation close to zero in the Rylington Park resistant line but moderately negative in the three other lines.

Table 2. Correlation (COR) between liveweight gain (LWG) and faecal egg count (FEC) and level of significance for differences between correlations within line (INT)

			Rylington Park		Haemonchus	
Period of LWG	COR	INT	Control	Resistant	Control	Resistant
			LWG and 1st FEC			
13 Feb - 28 Mar	-0.03	NS				
28 Mar - 9 May	-0.08	NS				
9 May - 20 Jun	0.03	NS				
20 Jun - 7 Aug	0.00	NS				
7 Aug - 18 Sep	-0.25***	NS	-0.43***	-0.13	-0.28	-0.22*
18 Sep - 29 Oct	-0.18**	NS	0.03	-0.22	-0.37**	-0.15
29 Oct - 4 Dec	-0.12*	NS	-0.29*	-0.06	0.01	-0.14
			LWG and 2nd FEC			
13 Feb - 28 Mar	0.06	NS				
28 Mar - 9 May	-0.14*	NS	-0.03	-0.19	-0.15	-0.15
9 May - 20 Jun	0.00	NS				
20 Jun - 7 Aug	-0.01	NS				
7 Aug - 18 Sep	-0.30***	*	-0.35**	0.04	-0.50***	-0.36***
18 Sep - 29 Oct	-0.17**	NS	0.06	-0.21	-0.24	-0.22*
29 Oct - 4 Dec	-0.12*	NS	-0.25	-0.21	0.01	-0.07
			LWG and average FEC			
13 Feb - 28 Mar	0.03	NS				
28 Mar - 9 May	-0.15**	NS	-0.03	-0.18	-0.25	-0.13
9 May - 20 Jun	0.02	NS				
20 Jun - 7 Aug	0.00	NS				
7 Aug - 18 Sep	-0.31***	NS	-0.45***	-0.06	-0.48**	-0.32**
18 Sep - 29 Oct	-0.20***	NS	0.05	-0.26*	-0.36**	-0.21*
29 Oct - 4 Dec	-0.14*	NS	-0.33**	-0.16	-0.02	-0.11

* $P<0.05$; ** $P<0.01$; *** $P<0.001$.

The experiment was not designed to compare the Rylington Park and Haemonchus flocks and differences in liveweight, LWG and FEC could be attributed to a number of reasons (different base genotype, sampling of sires, AI versus natural mating, different management from lambing to weaning).

With a field experiment it is difficult to separate the effects (and interaction) of nutrition, level and type of worm challenge and developing host immunity, factors that directly contribute to animal productivity and parasite burdens. However, there are some patterns in the results that suggest possible mechanisms influencing the relationship between worm burden and LWG. Conditions under which a significant relationship between LWG and FEC was evident appear to be independent of nutritional status and mean FEC; the relationship is apparent when sheep are both losing weight and rapidly gaining weight and at high and low FEC. The significant favourable relationship between LWG and FEC was consistently observed after the sheep reached 10 months of age, indicating some possible influence of age or acquired immunity. Consistent differences in mean FEC between the lines also appeared at the same age, suggesting that the animals required a period of worm exposure before the benefits of selection were expressed. This pattern is consistent with development of enhanced acquired immunity in selected sheep, the likely mechanism operating in sheep bred for worm resistance (Windon *et al.,* 1993). These results suggest that before young sheep have built up acquired immunity to worms, varying levels of infection between individuals have little effect on LWG. Once there is acquired immunity, sheep with lower worm burdens tend to show better LWG performance.

CONCLUSION

Although the negative correlation between liveweight gain and FEC, on occasions, was strong and, on occasions, the lines did vary by almost a factor of two for FEC in favour of the resistant line, a significant difference in average LWG between resistant and control lines was generally not observed. The trend was in the expected direction but only on one occasion was the difference statistically significant. Increased numbers of sheep may be needed to reliably demonstrate differences. However, these results do not suggest that sheep suffer a production penalty by being able to resist worm infection, and their survival may be higher. Worm infection can depress feed intake, therefore, it may be useful to include this measurement in follow-up studies to better understand the relationship between worm burden and productivity. As the relationship between FEC and LWG was sporadic from weaning to 11 months of age, it is unlikely that farmers would observe any difference in performance between sheep of varying resistance levels. The major advantages of breeding for worm resistance remain the ability to produce sheep that should have a lower requirement for anthelmintic treatment, better survival and that cause less pasture contamination and subsequent re-infection.

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