Reproduction in flocks selected for and against lamb faecal egg count

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ABSTRACT

Fifty nine mixed age ewes from high (H) and low (L) faecal egg count (FEC) selection lines were used in a MOET programme. Three years of reproductive data were also recorded in 714 ewes from the 2 selection lines and their control line (C). The mean (±SEM) total number of follicles >1.5 mm diameter on the surface of the ovary was higher ($P<0.05$) in L compared with H ewes (13.2 ± 0.9 and 10.9 ± 0.9). Embryo survival rate was 86% in L ewes and 60% in H ewes ($P<0.05$).

Ewe fertility, litter size, lamb survival and weaning rate in H, C and L ewes were 72%, 73% and 75%; 1.40, 1.43 and 1.47; 71%, 77% and 77%; and 72%, 80% and 84%.

These results demonstrate that some reproductive parameters are higher in L ewes compared with H ewes. There is some direct evidence (from MOET studies) as well as indirect evidence (from flock litter size data) that embryo survival is enhanced in L ewes. It is unlikely that this is a correlated genetic response, but is more likely an effect of the foundation ewes selected.

Keywords Sheep, internal parasites, reproduction, MOET, embryo survival, selection lines, FEC.

INTRODUCTION

Internal parasites in sheep have traditionally been controlled by anthelmintic drenching. In an attempt to minimise the use of anthelmintics, integrated grazing management systems have been developed, but their uptake by the industry has been low (Brunsdon, 1975; Lewis and Mason, 1980; McAnulty *et al.*, 1982). As a result, anthelmintics have continued to be the major strategy to control internal parasites. The recent development of resistance of sheep nematodes to anthelmintics highlights the problem of reliance on anthelmintics (Waller, 1986). This fact, coupled with the unlikely release of new anthelmintic families over the next decade or so, has hastened the search for alternative approaches. Genetic resistance to helminth infection has been demonstrated in Scottish Blackface sheep (Altaif *et al.*, 1978). Genetic variation in internal parasite worm burdens as assessed by lamb faecal egg count (FEC) has been shown in Romney ewes, and moderate heritability estimates obtained (Watson *et al.*, 1986). Selection lines for high (H) and low (L) FEC have been established by Wallaceville Research Centre in 1979 and by Ruakura Agricultural Centre since 1985. Recent genetic analyses have confirmed that FEC in lambs is moderately heritable (Baker *et al.*, 1991). The purpose of this study is to report on some reproduction parameters in the divergent Ruakura FEC selection lines and their controls based near Ruakura Agricultural Centre. Some history of the flocks has previously been published (Baker *et al.*, 1990).

MATERIALS AND METHODS

Experiment 1

Fifty nine mixed age Romney ewes and 8 18-month old rams based at the Tokanui Research Station, Te Awamutu, were transferred to Whatawhata Research Centre in early February 1991. Half of the ewes were from the Ruakura high lamb FEC selection line (H) and had the highest breeding values for FEC. The remaining half were ewes from the low lamb FEC line (L) and had the lowest breeding values. To synchronise oestrus, a CIDR-G™ device (Carter Holt Harvey, Hamilton, NZ) was inserted into each ewe in mid-March and withdrawn 12 days later. Approximately 8 days after oestrus (i.e. during the oestrous cycle), ovulation rates and the total number of surface ovarian follicles >1.5 mm in diameter were determined by laparoscopy as previously described (McMillan and Hall, 1991), and another CIDR-G™ device was inserted. Ten days later, another follicle count was taken and superovulation treatment with twice daily injections over 3 days of a total of 10.8 ml of ovine FSH (Ovagen™, Immuno Chemical Products, Auckland, NZ) and 300 iu of PMSG (Folligon, Intervet, Holland) commenced (McMillan and Hall, 1991). CIDR-G™ devices were removed two days later with heat detection thrice daily and oestrous ewes were hand-mated to rams from their respective selection lines until the cessation of oestrus. Six days after the onset of oestrus, superovulation rates were assessed and embryos recovered, assessed and transferred (mainly in pairs) to recipient ewes. After 45-50 days recipient ewes were scanned to determine foetal number.

Experiment 2

Approximately 80 ewes per year in the H (range 81-95 ewes), L (range 63-87 ewes) and Control (C, range 57-89 ewes) FEC selection lines (total of 714 ewes) were single-sire mated for about 8 weeks to rams from their respective selection lines over the 2 years 1989 and 1990. In 1991, ewes were mated for 2 cycles only following a synchrony treatment. The 1991 data included ewes previously used as donors, and then naturally mated for 2 cycles. Records were taken of the number of lambs born per ewe at lambing and the number of lambs weaned. From these data, ewe fertility (ewes lambing per 100 ewes joined with the ram and surviving to lambing), litter size (lambs born per ewe lambing) and lamb survival (lambs weaned per 100 lambs born) were calculated.

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Data analysis

The data in Experiment 1 were analysed by ANOVA techniques and least squares means are presented. In the case of fertilisation rate (eggs fertilised/eggs recovered) and embryo survival rate (foetuses present/embryo transferred), effects for individual rams were fitted. Egg recovery (eggs recovered/ ovulation), fertilisation and embryo survival rates were analysed on a ewe basis and not an egg or embryo basis. Comparisons among selection lines for ewe fertility, litter size (analysed as ewes lambing multiples/ewe lambing) and lamb survival in Experiment 2 were by chi-square contingency analysis (Snedecor and Cochran, 1967).

RESULTS

Experiment 1

Ovarian activity

The mean total ovarian follicle numbers during the oestrous cycle was 12.1±0.9. There were more follicles on the ovaries of L compared with H ewes (13.2 vs 10.9, P<0.05) (Table 1). Ten days later at the start of superovulation treatment, the mean follicle number was 13.8±0.9. Again, follicle numbers were higher in L compared with H ewes (14.8 vs 12.7) (P<0.05). Although approximately two thirds of the follicles were between 1.5 and 3 mm in diameter, there was little difference between the 2 selection lines in follicles of this diameter (overall, 8.9 vs 8.4). Mean ovulation rate during the oestrous cycle was 1.5 ±0.1 in each line of ewes. After superovulation treatment, the mean superovulation rate was 10.8±0.8 and was not significantly different in the L and H selection lines (11.8 vs 9.8).

Interval to onset of oestrus

The interval from CIDR-G™ device removal to the recorded onset of oestrus was similar in both selection lines (25.1 vs 26.6 h, SEM=1.1 h).

TABLE 1 Reproductive parameters in Low and High FEC ewes undergoing MOET procedures in 1991 (Experiment 1)

	Low FEC	High FEC	Significance
Number of donor ewes	30	29	
Ovulation rate	1.5	1.5	
Follicles during cycle	13.2	10.9	P<0.05
Follicles at start of superovulation treatment	14.8	12.7	P<0.05
Interval to onset of oestrus, h	25.1	26.6	
Superovulation rate	11.8	9.8	
Fertilisation rate %			
Ram 1	20	0	
Ram 2	64	65	
Ram 3	71	68	
Ram 4	91	81	
Overall	62	54	
Embryo survival %			
Ram 1	100	-	
Ram 2	80	58	
Ram 3	80	50	
Ram 4	82	73	
Overall	86	60	P<0.05

Egg recovery, fertilisation and embryo survival

Overall, 50% of the eggs were recovered from L and H ewes. Of the recovered eggs, 58% were fertilised. There was considerable variation among rams in their fertilisation rate (Table 1). The best ram achieved over a 90% fertilisation rate compared with 0% by the worst ram. As a result of the overlap in fertilisation rate between L and H rams, there was no significant effect of selection line on the overall fertilisation rate (62% vs 54%). There was also considerable variation between rams in the survival of embryos (Table 1). Unlike the situation for fertilisation rate, there was no overlap in the embryo survival rate of rams from the 2 selection lines (80-100% in L line vs 50-73%) in H line embryos. Overall, embryo survival was higher in embryos from the L line compared with the H selection line (86% vs 60%, P<0.05).

TABLE 2 Mean reproductive performance in High, Control and Low FEC selection line ewes during 1989-91.

	No ewes	Ewes lambing/ ewe joined[a] (%)	Lambs born/ ewe lambing (%)	Lambs weaned/ lamb born (%)	Lambs weaned/ ewe joined[a] (%)
1989					
High FEC	95	83	148	73	89
Control FEC	76	78	151	72	84
Low FEC	87	71	155	77	85
1990					
High FEC	84	63	143	71	64
Control FEC	57	65	149	78	75
Low FEC	63	78	147	68	78
1991					
High FEC	81	67	126	69	58
Control FEC	89	73	132	83	80
Low FEC	82	77	138	83	88

[a]And present at lambing

Experiment 2

Overall 73% (521/714) of ewes joined with the ram had lambed, with only a small effect of line (Table 2). C ewes ranked in the middle for ewe fertility for each of the 3 years, with L ewes ranking highest in 2 of the 3 years. Overall, litter size was 1.43. with a consistent trend over the 3 years for H ewes to be lower than L ewes (Table 2). However, none of the yearly differences (maximum Chi-square=1.98, 1 d.f), nor the pooled difference (Chi square=1.42, 1 d.f) was significant. Litter size in C ewes was ranked intermediate for 2 of the 3 years. The trend was also for litter size to be higher in L compared with H ex-donors following natural mating (1.38 vs 1.27). The combined effect of ewe fertility and litter size was 101 lambs born per 100 ewes to the ram in H ewes compared with 104 and 110 in C and L ewes respectively. Averaged over the 3 years, lamb survival was the same in C and L lines (77%), but these combined were not significantly higher than the 71% survival rate in the H line (Chi square=2.8, 1 d.f.)(Table 2). Overall, 72 lambs were weaned per 100 H ewes joined compared with 80 and 84 in C and L ewes respectively.

DISCUSSION

The major finding from this study was the effect of FEC selection on embryo survival. Embryo transfer provided direct evidence that L ewes, when mated with L rams, have embryos which are more likely to survive than are embryos from H ewes mated with H rams. Embryo survival in the H line (60%) appears higher than that reported in adult Romney ewes (53%, McMillan and McDonald, 1985) and adult Merino ewes (47%, Shackell and Isaacs, 1991) in other recent NZ studies. The 86% survival rate of embryos from L ewes is thus considerably higher than normally reported in ewes. An analysis of between ram variation in this parameter revealed that there was no overlap in the survival of embryos from L compared with H ewes.

Indirect evidence to support this finding comes from the lambing performance of the ewes in Experiment 2. In this study, the consistent trend was for litter size to be higher in L compared with H ewes, with C ewes intermediate. When taken together with the ovulation rate information from ewes during the oestrous cycle in Experiment 1 where no difference was found, it is reasonable to postulate that partial failure of multiple ovulation (i.e. the birth of one lamb after a twin ovulation) is the reason for the lower litter size in H ewes in Experiment 2. Partial failure of multiple ovulation is considered to be largely a consequence of partial embryo failure rather than partial failure of fertilisation. The incidence of partial fertilisation failure is normally less than 10% (Moore, 1981).

It is difficult to explain why embryo survival should be higher in L ewes. One possibility is that the immunological processes associated with low FEC (Douch, 1990) may impact on early embryo development and/or maternal recognition of pregnancy. The evidence from Experiment 1 shows that the difference is probably in embryo quality *per se* rather than a maternal uterine component, since all embryos were transferred at random into unrelated recipient ewes. A maternal component may be involved but this effect would have to occur before day 6, when embryos were recovered and transferred. Additional studies are required to test these suggestions. Alternatively, the result may be a chance effect associated with the foundation sheep in the selection flocks. Support for this alternative comes from the fact that a correlated selection response of the magnitude achieved would be extremely unlikely given the short selection history (1 generation) of ewes in the flock, and the low heritabilities for the trait under consideration. A further study is planned for autumn 1992 with Romney and Perendale H and L ewes. If differential embryo survival can be confirmed in divergent FEC selection line ewes in these 2 breeds, it would lessen the argument for a foundation ewe effect. However, the embryos from these ewes would be very useful models for future studies in embryo development and pregnancy recognition in grazing livestock. The absence of such a model is limiting current advances in this area.

The second key finding from this study was the 15-20% greater number of total follicles on the ovary surface in L ewes. Although approximately two thirds of the follicles were between 1.5 and 3 mm in diameter, there was little difference between the two selection lines in follicles of this diameter. The advantage to L ewes thus appears to arise from an accumulated advantage in follicle numbers across the spectrum of diameters assessed. This suggests that the dynamics of follicle turnover may be different in the two selection lines. The tendency for a higher superovulation response in Low FEC ewes (13.2 vs 10.9) is consistent with the proposition that follicle dynamics is altered in these ewes. Other studies are necessary to determine the basis of this difference.

The lambing data from Experiment 2 show little difference between selection lines in ewe fertility under single sire mating conditions, and lamb survival. The apparently low level of both of these parameters suggest that flock management is sub-optimal. Outbreaks of autumn facial eczema in 1989 (a severe season in the Waikato) and 1990 (36% of 290 lambs had elevated serum gamma glutamyl tranferase (GGT) levels) are possible explanations for sub-optimal flock performance. Over 95% of the donor ewes in 1991 (and ewe lambs) were assessed to have no sub-clinical liver damage according to GGT levels.

In summary, these two experiments provide evidence to support the proposition that reproductive patterns are different in ewes selected either for or against lamb faecal egg counts. The key reproductive differences are in embryo survival and ovarian activity. Additional studies will be conducted in 1992 to examine these two aspects of reproductive performance.

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