Effect of ewe ovulation rate and uterine efficiency on breed and strain variation in litter size

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ABSTRACT

Three lines differing markedly in reproductive performance as a result of long-term selection for litter size were compared for ovulation rates and uterine efficiency. Genetic differences in litter size were found to be due to genetic changes in ovulation rate with no evidence of altered uterine efficiency. Three additional lines also showed variation in litter size to be due to variation in ovulation rate rather than differences in uterine efficiency.

INTRODUCTION

A high reproductive rate in ewes increases both flock income from surplus stock and selection pressure in choosing replacements. Embryo transfer studies have indicated that ovulation rate is the major factor limiting litter size in sheep (Hanrahan, 1981). Therefore it is interesting to know whether genotypes differing in litter size are purely a reflection of variation in ovulation rate or if genetic variation also exists in efficiency of producing lambs from eggs ovulated.

EXPERIMENTAL DESIGN

Ovulation rate was measuresd by laparoscopy in 6 genotypes of ewes mated at the Tokanui Research Station in 1981. These were the Ruakura Fertility lines (High, Control and Low) initiated in 1948 (Wallace, 1964), and selection lines of Romney, Border Leicester (BL) and Border x Romney (BL x R) origin. The latter 3 lines were initiated in 1969 and mated since 1973 as closed flocks. The Romney line has beeen maintained under random selection while the BL and BL x R lines have both been selected on an index (based on yearling weight and dam fertility) designed to increase reproductive performance.

Ewes were single-sire paddock mated to harnessed rams of their respective lines. Weekly laparoscopies were undertaken from the start of mating to examine ewes recorded as being marked at least 2 days previously. Ewes returning to service were re-examined to determine ovulation rate (OR) at the eventual oestrus of conception.

The subsequent lambing record for each ewe was examined to assess litter size and birth date was checked against mating and laparoscopy records to eliminate animals which conceived to ovulations other than those observed.

A few ewes were credited with giving birth to more lambs than could be accommodated by the corresponding OR measure. Since it was impossible to tell in retrospect whether discrepancies were due to mismothering or to errors in determing OR, the record of OR at conception for such ewes was adjusted upward to match the lambing record. This was done ignoring line and age of ewe involved.

RESULTS

Ruakura Fertility Lines

Mean OR recorded at the first observed oestrus is shown in Table 1. The 3 lines all differed from one another ($P<0.05$). Overall there was an age effect ($P<0.05$) but this was less for the High line than for the Control and Low lines.

Mean litter size of lambing ewe is shown in Table 2 along with the OR at the ovulation of conception.

TABLE 1 Mean 1981 ovulation rates (ewe numbers)

		Ewe birth year				
		1979	1978	1977	1976	Mean*
Fertility:	High	1.87 (30)	1.91 (11)	1.88 (8)	2.10 (10)	1.96
	Control	1.26 (19)	1.43 (14)	1.60 (15)	1.71 (7)	1.47
	Low	1.06 (18)	1.25 (8)	1.25 (8)	1.40 (10)	1.22
Selection:	Romney	1.50 (24)	1.76 (25)	1.75 (16)	1.71 (17)	1.67
	BL x R	1.50 (24)	1.87 (23)	2.14 (21)	2.12 (17)	1.90
	BL	1.91 (23)	1.86 (22)	1.95 (21)	2.06 (17)	1.94

* Least squares means.

Litter size was significantly higher for the High line but did not differ between the Control and Low lines. Also shown is an estimate of uterine efficiency calculated as the proportion of additional eggs (after the first) represented by additional lambs born. Values were calculated for each age class then pooled within line. Estimates did not differ between the High and Control lines. Incidence of multiple ovulations was too low in the Low line to provide a reliable estimate.

TABLE 2 Mean ovulation rates (OR), uterine efficiency (UE) and litter size (LS) for lambing ewes

		OR	UE*	LS
Fertility:	High	2.06	.60	1.67
	Control	1.48	.67	1.28
	Low	1.26	—	1.17
Selection	Romney	1.74	.57	1.43
	BL x R	1.99	.70	1.70
	BL	2.14	.62	1.70

* See text.

Selection Lines

Similar results for the selection lines are also shown in Tables 1 and 2. OR did not differ significantly between the BL and BL x R lines but were significantly higher ($P<0.01$) than for the Romney line. OR increased ($P<0.01$) with increasing ewe age, but less so for the BL than for the other 2 lines.

Litter size was similar to OR in being lower for the Romneys and not differing between the other 2 breeds. The estimate of uterine efficiency was highest for the BL x R line but did not differ significantly over genotypes. When results were pooled across lines within ewe age, litter size increases paralleled the OR increase with age and there were no differences in uterine efficiency for the 4 age classes.

DISCUSSION

The pattern of OR for the 3 Fertility lines and the lack of difference in uterine efficiency between the High and Control line clearly indicate that successful long-term selection for litter size has been manifest primarily through changes in OR. Directional selection was discontinued in 1972 and the lines have since been randomly selected. The 1981 litter size showed a difference of .50 lambs between the High and Low lines compared to a value of .52 reported by Clarke (1975) for the mean of years 1968/72, indicating that relaxed selection over the last 9 years has not diminished the genetic differences previously achieved for litter size.

In both the High and Low lines the OR differences from the Control, in terms of proportion of ewes with multiple ovulations, were largest for two-tooths and diminished with increasing age. This pattern has been reported previously for Finn crosses (Meyer, 1979) and has been observed in several recent trials involving Booroola Merino-derived genotypes. It thus appears that genetic variation in OR, whether between breeds or arising from selection for fertility within breeds, may be greatest in young ewes and decrease with age.

Mating weights for mature ewes were consistently 2 to 3 kg heavier over age groups for the High line than for the Low line. However, the two-tooth weights favoured the Low line by about 1 kg, probably a carryover effect of the much higher incidence of twin-born ewes in the High line. The Control line was consistently the heaviest line of the 3, averaging 4 kg more than the High line (Control average of 56 kg at mating). As previously mentioned by Clarke (1972), this is probably due to the practice of selecting 'good' (larger?) sheep in the Control during the early years while High and Low line selection was based exclusively on reproductive performance. Thus, any interpretation of body weight differences as correlated responses to litter-size seleciton is limited to the High and Low lines.

The 3 selection lines provide an interesting comparison because the BL x R line is based on the same genetic material as the BL and Romney lines. Differences in BL x R performance from the parental breed midpoint are thus due to combined effects of heterosis in the interbreds plus ovulation selection responses which have accrued over the short selection history. BL x R mating weights were about 5% above the Romney-BL midpoint, indicating heterotic effects of about 10% on the assumption that selection has produced little body weight change. OR for the BL x R line, when measured as the proportion of ewes exhibiting multiple ovulations, were 11% above the parental breed midpoint and approaching the BL mean. It will be interesting to observe the future response in these 2 genotypes as they continue to be selected on the same criteria.

The Romney selection line and Fertility Control line were at the same mating weights but differed markedly in their pattern of OR relative to age. The advantage of the Romney line was largest in the two-tooths and decreased with age. The differences might be due either to adverse inbreeding effects within the Control line or to differences in gene frequencies affecting OR in the two flocks.

Comparison of uterine efficiency across all genotypes and across all ages within the Selection lines gives little indication of either genetic or age effects for the groups of sheep observed. There is likewise no strong evidence that genetic variation in litter size is due to variation in uterine efficiency.

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