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Repeatability of reproductive performance following active immunisation of ewes

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ABSTRACT

Data from mature ewes repeatedly re-immunised against androstenedione or oestrone in 3 trials at the Ruakura (Coopworths), Wairakei (Perendales) and Whatawhata (Romneys, Coopworths and Perendales) Animal Research Stations, were analysed to estimate the repeatability of ovulation rate and number of lambs born per ewe.

Immunisation responses were within the range of those reported previously (Smith, 1985). Between-year repeatability estimates were on average similar for immunised and non-immunised ewes. The unweighted average of the estimates was 0.29 for ovulation rate and 0.09 for number of lambs born, consistent with published values. The results suggest that the joint contribution of genetic and permanent environmental sources of variation to phenotypic differences between animals is similar under both physiological states. The high repeatability of ovulation rate in comparison with number of lambs born supports other published indications of its possible value for improvement of reproductive rate through selection.

Keywords Repeatability; ovulation rate; ewes; immunisation; fecundity

INTRODUCTION

Implications of active immunisation of ewes against their steroid reproductive hormones to programmes of genetic improvement have been discussed (Clarke, 1985). The indirect or consequential effects of improved reproductive rate on breeding objectives and the intensity of selection were able to be considered without any prior knowledge of the effects of immunisation on the physiological genetic control of reproductive performance. This was not true, however, for the effects of immunisation on the amount and nature of genetic variation displayed by immunised ewes and, therefore, whether selection among them would be capable of bringing about genetic improvement of reproductive rate. As a preliminary guideline, this paper analyses data on the repeatability of ovulation rate (OR) and number of lambs born per ewe (NLB) for ewes repeatedly immunised over several years in comparison with non-immunised controls.

MATERIALS AND METHODS

The data came from 3 trials set up to study the long-term effects of re-immunisation.

Trial 1. For mating at Ruakura Animal Research Station 1982, 360 2½-year-old Coopworth ewes were purchased from a single source and randomly allocated on the basis of live weight to 3 treatment groups: immunised against Fecundin[®] (Glaxo NZ Ltd), a commercial androstenedione antigen, immunised against a locally prepared oestrone antigen, and non-immunised controls. Treated

ewes received their primary and secondary injections of antigen 7 and 3 weeks before the introduction of rams on 27 March 1982. In 1983 and 1984 they received a booster injection 3 weeks before joining at the same time of the year. Once each week, ewes marked by the Suffolk rams were laparoscoped to determine ovulation rate. Ewes were set-stocked at 21/ha on ryegrass-white clover pastures with each treatment group receiving one-third of each ha over a 17 ha farmlet. Management procedures and staff were the same each year.

Trial 2. Two-tooth Perendale ewes at Wairakei Research Station were randomly allocated to 3 groups on the basis of their dam's previous treatment, their birth rank, their own treatment as hoggets with iodine (no significant effects detected) and their live weight in February 1983. Immunisation treatments were the same as in Trial 1 but with ewes receiving their primary and secondary injections 8 and 4 weeks before rams were joined in late April and receiving boosters in subsequent years (1984 and 1985) 4 weeks before mating. Ewes were using synchronised progestagen sponges or progesterone CIDRs over a 14-day period, entire Perendale rams being joined 14 days after sponge or CIDR removal at the second synchronised oestrus. Ovulation rate was determined by laparoscopic examination on one occasion 7 to 10 days after oestrus was expected to have occurred. Ewes were rotationally grazed as one mob on ryegrass-clover pastures except for a period of 6 weeks commencing 3 weeks prior to mating when

half of each group was grazed on lucerne. They were initially stocked at a rate of 14 stock units/ha reducing to 12.2 stock units/ha from lambing 1983 for the remainder of the trial.

Trial 3. Lambing records came from a flock of mixed-age Romney, Coopworth and Perendale ewes (180 to 200 of each breed) run at the Whatawhata Hill Country Research Station. Treated ewes were immunised with 'Fecundin' 6 and 3 weeks before joining and received booster injections in following years 3 weeks before matings to rams of their own breed. Ewes were culled from the flock following their 5-year-old lambing. The trial commenced with 3- to 5-year old ewes at lambing in 1983, an additional 70 to 80 3-year-olds being included each year. Thus in contrast to the previous 2 trials, different crops of ewes were treated each year. Other management details of this trial are described by Knight *et al.* (1985).

Lambing and ovulation rate data were analysed using the Restricted Maximum Likelihood (REML) technique (Patterson and Thompson, 1971) with ewe included as a random element for which variance components were estimated. Fixed effects included immunisation treatment and year of record for Trial 1 as well as grazing group for Trial 2 and breed and age of ewe for Trial 3.

A between-ewe variance component was also estimated on an underlying scale of liability (using program REG; Gilmour (1983) with thresholds defining the appropriate categories of response: 1, 2, 3 ovulations and 0, 1, 2, 3 lambs born. The fixed and random effects are assumed to be additive on the underlying scale, the logistic distribution being used to describe variation on this scale (Gilmour, 1983).

RESULTS

Estimated means and average standard errors of differences (s.e.d.) for main effects are presented in Table 1. In Trial 1, there was no significant treatment x year interaction for OR or NLB and no effect of either immunisation or year on 'embryo survival' as determined by the difference between these 2 characters. In Trial 2, all 2-factor interactions among immunisation treatment, grazing group and year were significant for OR and to a lesser extent for NLB but in no case was there a change in the ranking of main effects. In Trial 3, Table 1 presents age of ewe rather than year effects since 4 different crops of ewes had repeated records in the flock between 1983 and 1985. For OR, there was a significant interaction between treatment and year but no change in ranking for the immunised ewes. There was no interaction between breed and treatment.

TABLE 1 Estimates of main effects on ovulation rate (OR) and number of lambs born/ewe (NLB).

	Trial 1 (Coopworths)		NLB	Trial 2 (Perendales)		NLB	Trial 3 (Mixed Breed)		
	No. ^a	OR		No. ^a	OR		No. ^{ab}	OR	NLB
Treatment									
Control	100	1.60	1.28	109	1.37	1.16	546	1.66	1.36
Andros.	100	2.32	1.52	111	1.94	1.29	525	2.12	1.56
Oestrone	99	2.11	1.58	116	1.51	1.20			
s.e.d.		0.07	0.06		0.06	0.06		0.04	0.04
Year/age	Yr			Yr			Age (Yrs)		
	'83	1.68	1.44	'83	1.50	1.14	3	1.83	1.38
	'84	1.92	1.41	'84	1.59	1.19	4	1.91	1.49
	'85	2.44	1.53	'85	1.73	1.33	5	1.94	1.51
s.e.d.		0.05	0.05		0.04	0.04		0.04	0.04
Grazing Group									
Grass					1.70	1.30			
Lucerne					1.51	1.14			
s.e.d.					0.05	0.05			
Breed									
Romney							338	1.79	1.34
Perendale							374	1.87	1.48
Coopworth							359	2.02	1.56
s.e.d.								0.05	0.04

s.e.d. average standard error of differences among main effects

a number of ewes with ovulation records over each of the 3 years

b for trial 3, total number of OR records is 1820

Averaged over the 3 trials the androstenedione-treated ewes had 0.58 more ovulations and 0.19 more lambs than the controls; the corresponding figures for oestrone were 0.33 and 0.17.

On average there was no consistent difference between the estimates of repeatability in immunised and control ewes for either OR or NLB on either the observed (Table 1) or transformed scales (Table 2). On the underlying scales the unweighted average of the pooled estimates was 0.37 and 0.11 for OR and NLB, respectively. On the observed scale the average of the pooled estimates for OR was 0.29. For NLB, the average of the pooled values was 0.09 falling between the average of the estimates for ewe fertility (0.06) and litter size (0.15) reviewed by Land *et al.* (1983). Eliminating barren ewes from the analysis of Trial 1 data on the underlying scale raised the estimate of the pooled repeatability for litter size to 0.09 from the lower value of 0.03 shown in Table 3. Such re-analysis made little difference in Trial 2.

DISCUSSION

A repeatability analysis of successive records of the same animals is able to give some idea of the upper level of genetic determination for a character. The repeatability is a ratio of variance components (Falconer, 1981). The numerator of the ratio (to total variation) is an estimate of the between-animal component representing circumstances which give rise to permanent differences between animals due to genetic or permanent environmental effects. The residual within-animal component of total variation represents the remaining, temporary environmental circumstances which cause animals to express themselves differently each year. Thus, the repeatability reflects the joint importance of differences among animals due to their breeding value, non-additive genetic values and permanent environmental effects. By contrast, the heritability which is closely related to the accuracy of selection, reflects the importance of differences due only to additive breeding value effects.

For reproductive performance under natural lambing, Land *et al.* (1983) report average repeatability and heritability estimates of 0.06 and 0.07, respectively, for ewe fertility and 0.15 and 0.10 for litter size. As

illustrated by their review, repeatability estimates are generally similar to, or a little higher than, the corresponding heritability estimates. The average repeatability estimate for NLB in this study was 0.09, falling between these 2 extremes as would be expected since NLB includes both fertility and litter size components. The estimate is however a little lower than that from an earlier unpublished study (0.14) undertaken by the senior author in a randomly-bred non-immunised Romney flock at Massey University (Clarke, 1963). This estimate was, however based on a weighted regression technique (Turner and Young, 1969) which tends to give higher estimates than those based on intra-class correlations. When, for example, data from Trial 1 of the present study were analysed by this regression method, the estimate obtained for OR was 0.47 compared with the intra-class correlation estimate of 0.31 presented in Table 2.

That there was no difference between the estimates for immunised and non-immunised ewes, suggests that the joint contributions of genetic and permanent environmental source of variation to phenotypic differences between animals is similar under both physiological states. This repeatability analysis however, is unable to separate additive genetic from non-additive genetic and permanent environmental sources of variation and therefore can make no firm conclusions about the responsiveness of NLB following immunisation to selection for improved reproductive performance. Nor can it indicate whether any responses that might arise from exploitation of additive genetic (breeding value) differences among animals through selection would give associated genetic improvements in reproductive performance under a non-immunisation regime. These possibilities were more fully discussed by Clarke (1985).

The repeatability of ovulation rate was also similar for immunised and non-immunised ewes with little variation among trials and immunisation treatments especially when these estimates are considered in relation to the variation among estimates from studies on non-immunised ewes summarised by Hanrahan and Quirke (1984). This review indicates breed variation in the repeatability of ovulation rate among non-immunised ewes, with a suggestion of lower repeatability

TABLE 2 Repeatability estimates of untransformed data for OR and NLB.

	Ovulation rate			Number of lambs born		
	Trial 1	Trial 2	Trial 3	Trial 1	Trial 2	Trial 3
Control	0.33±0.06	0.12±0.06	0.34±0.04	0.02±0.06	0.18±0.06	0.10±0.05
Andros.	0.31±0.06	0.30±0.06	0.34±0.05	0.09±0.06	0.21±0.06	0.06±0.05
Oestrone	0.31±0.07	0.20±0.06		0	0.10±0.06	
Pooled	0.31±0.04	0.23±0.04	0.34±0.03	0.03±0.04	0.17±0.04	0.08±0.04

(and heritability) for breeds of high compared with those of low average fecundity. The average value for the inter-year repeatability of ovulation rate reported by Hanrahan and Quirke (1984) is the same as that presented in Table 2 (0.29).

The variation among estimates in this study was only a little less when data were analysed on an underlying logistic scale in an attempt to take account of scale effects associated with the different distribution of OR for different treatments within each trial.

There was no good evidence in this study for the estimates of repeatability of OR to be associated with breed of ewe. On the underlying scale the repeatability estimates for the Romney, Perendale and Coopworth ewes run together in Trial 3 were 0.48, 0.35 and 0.33 respectively. Hanrahan and Quirke (1984) suggest that a higher heritability and repeatability of ovulation rate compared to litter size is to be expected on the basis of the model proposed by Hanrahan (1980) that there is no permanent variation among ewes in the probability of embryo survival, which itself shows a strong negative relationship with the number of ova shed. Under this model, genetic and permanent environmental differences among animals for ovulation rate would be masked when these are assessed on the basis of litter size records and this effect would be more pronounced for the more prolific breeds.

On the surface, results from Trial 3 are not compatible with this model in that the pooled breed estimates of repeatability for NLB on the underlying scale ranked the breeds in the reverse order to their fecundity—Romney 0.03, Perendale 0.10 and Coopworth 0.21—the pooled repeatability value being 0.10 as shown in Table 3. While breed differences in this trial are not as extreme as those considered by Hanrahan and Quirke (1984), it is interesting that the Romney, which showed the highest repeatability for ovulation rate and the lowest repeatability for number of lambs born, was the breed which gave the greatest ovulation rate response to immunisation (Knight *et al.* 1985). Furthermore, variation from non-additive genetic and permanent environmental effects could be involved in this repeatability study which includes immunised as well as naturally reproducing ewes. Many immunised sheep in this trial failed to produce as many lambs as expected from their ovulation rate, a feature of immunisation which may have a genetic or environmental basis compared with natural reproduction.

The results from this study nevertheless add some support to the proposal that ovulation records could be of value to the improvement of reproductive rate through selection, especially the high repeatabilities shown on the underlying scale as well as on the observed scale of measurement.

TABLE 3 Repeatability estimates on transformed underlying scale.

	Ovulation rate ^a			Number of lambs ^b		
	Trial 1	Trial 2	Trial 3	Trial 1	Trial 2	Trial 3
Control	0.50	0.22	0.39	0.02	0.23	0.14
Andros.	0.34	0.36	0.39	0.08	0.24	0.06
Oestrone	0.39	0.29		0.03	0.15	
Pooled	0.38	0.32	0.40	0.03	0.20	0.10

^a OR transformed as a discrete 3-class response variable (1, 2 and 3 ovulations)

^b NLB transformed as a discrete 4-class response variable (0, 1, 2 and 3 lambs)

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