
THE PROCEEDINGS OF THE
NEW ZEALAND SOCIETY
OF
ANIMAL PRODUCTION
VOLUME 62 2002

Genetic parameters and performance of flocks selected for advanced lambing date

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ABSTRACT

Data for the years 1986 to 1990 from the "Kamo" out-of-season lambing flock were subjected to analyses to determine the genetic variation for lambing date. The response variate was date of lambing (provided the ewe had a chance to mate for an autumn lambing) and this was transformed to an underlying normal scale by treating it as an ordered categorical response. Restricted maximum likelihood (REML) analyses were performed using an animal model. Year of record and age of ewe were included as fixed effects. There were 870 ewes having a total of 1967 lambing records. The estimate of heritability for standardised lambing date was 0.23 and repeatability 0.36 while the heritability for litter size was 0.03. Preliminary multivariate analysis indicated that the genetic correlation between standardised lambing date and litter size to be 0.09.

At the time of disbanding of the flock samples of ewes selected on the phenotypic response (i.e. number of times lambed in autumn) of the ewe or of her dam, were brought to Ruakura. In 1991 following a best linear unbiased prediction (BLUP) analyses these were assigned to Autumn and Spring lambing flocks on the basis of their breeding value (BV) for standardised date of lambing. The average BV for the Autumn flock was -0.13 while that for spring was +0.07 and there was a 26 day difference in mean lambing date (167 vs 193).

Keywords Out-of-season lambing, heritability, genetic parameters, lambing performance, litter size, selection, breeding values, lambing date, season.

INTRODUCTION

In the last decade there has been continual interest in the need for an expansion of the sheep breeding season in New Zealand. This is required to accommodate both the differences in regional climate patterns and thus pasture growth, and the increasing requirements for the chilled meat trade (larger lean lambs throughout the year). While hormonal and other techniques have been shown to successfully advance the breeding season of sheep breeds in New Zealand (Smith *et al.*, 1989) these increase the cost of production and may have marketing ramifications in the future. It has been demonstrated that selection for earlier lambing can result in flocks with advanced lambing patterns in a number of breeds (Fahmy, 1982; Thrift *et al.*, 1971; McQueen and Reid, 1988).

In New Zealand this has been confined to crosses involving the Polled Dorset breed (Andrews, 1983; McQueen and Reid, 1988) and no analysis of the genetic parameters within these flocks have been presented.

This paper presents the results of the analyses of data from one of these flocks and outlines the breeding management and selection programme that has been devised with the future aim of determining what factor regulating seasonal breeding has been changed by the selection for autumn lambing.

MATERIALS AND METHODS

The Flock

The flock involved was the "Kamo" Polled Dorset x Romney crossbred flock that had been selected for early lambing (McQueen and Reid, 1988). This flock originated in 1971 with production of Polled Dorset x Romney ewes on the Waikato property of Mr B. Hall. From there they went to Whatawhata Hill Country Research Station under control of Dr D.C. Dalton where they were mated with Dorset x Romney rams to generate the F_2 etc. In 1976 the flock was transferred to Northland and selection for early lambing commenced. This has been detailed by McQueen and Reid (1988). In 1990 the flock was disbanded and selected ewes were brought to Ruakura Agricultural Centre. These animals were selected (both for and against) on the basis of phenotypic response (i.e. number of times lambed in the autumn) of the ewe or of her dam and assigned to autumn and spring mating flocks.

Data Analyses

The data used was obtained from a SIR data base which recorded the productive performance (reproduction, wool production, liveweight) of the "Kamo" flock from 1985 onwards. The purpose of this study was to estimate the genetic and permanent environmental variation for lambing date.

Analysis was carried out by Restricted Maximum Likelihood (REML) fitting an animal model and using all pedigree information available. A derivate-free algorithm was used in programme DFREML (Meyer, 1988, 1989). Year of record (1986 to 1991) and age of ewe (2, 3, 4, ≥5 year old) were included as fixed effects. The additive genetic effect due to each animal was included as a random effect and repeated records were accounted for by inclusion of an additional permanent environmental effect or equivalently by allowing for a covariance among residuals.

The response variate of main interest was date of lambing for those ewes given the opportunity to lamb in autumn (i.e. joined in early summer). The data was transformed to an underlying normal variable by treating date of lambing as an ordered categorical response (Gianola and Norton, 1981). This was done to take account of the bimodality of date of lambing (produced by removal of rams - see mating management) and to assign a value to those animals that did not lamb (standardised lambing date).

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Litter size was also analysed using the same repeatability model. The genetic correlation between standardised lambing date and litter size was determined by multivariate analysis.

Breeding values (BV) for standardised lambing date were calculated using best linear unbiased prediction (BLUP) procedures and are expressed in standard deviation units

Mating Management

Ewes were joined in November for about 8 weeks. The rams were removed and non-pregnant ewes re-joined in March/April. This produced two distinct lambing periods April/May and August/September.

The modifications since location at Ruakura include selection of replacements, both rams and ewes, on basis of BVs for standardised date of lambing. All ewes in the respective flocks are single sire mated to low (- ve) BV rams in Nov-Jan and to high (+ ve) BV rams in March/April.

RESULTS

There were 1051 animals in the model with 506 dams (ewes with daughters having lambing records in period analysed) and of these 337 had lambing records of their own in the period. Overall there were 870 ewes having a total of 1969 lambing records in the period. This distribution of the number of records per ewe is summarised in Table 1. Only 11 sires were identified to a total of 343 progeny records (daughters that lambed in the period) as single sire mating commenced in the flock in 1987. Thus much of the genetic information was derived from dam-offspring relationships.

TABLE 1 Distribution of ewes by number of opportunities to lamb in autumn between 1986 and 1991.

No. records	No ewes
1	310
2	240
3	162
4	103
5	49
6	6
	870

Estimates of variance components and the resulting genetic parameters are given in Table 2. The estimate of heritability for standardised lambing date was 0.23 and that for litter size was 0.03. The repeatability of standardised date of lambing was 0.36 and for litter size it was 0.10.

TABLE 2 Variance components and genetic parameters

	Standardised lambing date	Actual lambing date	Litter size
No. records	1969	1755	1969
Additive genetic (direct) variance	.21	741	.0096
Permanent environmental variance	.12	299	.0188
Residual variance	.60	1375	.2632
Heritability	.23 ± .05	.31 ± .06	.03 ± .03
Repeatability	.36 ± .03	.43 ± .03	.10 ± .03
Phenotypic Std dev.	.97	49	.54

Preliminary analysis indicated that the genetic correlation between standardised lambing date and litter size was 0.09 while the phenotypic correlation was 0.02.

Ewe age was included in the analyses as a fixed effect and Table 3 presents the frequency distribution of lambing (autumn or spring) for each age group over the period of the analysis which indicates a lower proportion of the 2 year old ewes lambing in autumn compared to the other age groups.

TABLE 3 Age effect on lambing distribution for the years 1986-1990 (% of flock)

Age (yrs)	No. Observations	Season of lambing Autumn	Spring	Dry
2	684	44	44	11
3	476	69	22	9
4	338	74	18	9
5+	471	70	16	13
Overall	1969	62	28	11

Table 4 presents the mean birth days for the autumn and spring lambings over the period of the analysis.

TABLE 4 Mean birth day (% of flock)

Year	Season of lambing Autumn		Spring		Dry
86	114.0	(77)	233.8	(16)	(6)
87	114.0	(69)	248.9	(25)	(6)
88	115.3	(66)	242.9	(27)	(7)
89	119.7	(63)	231.0	(29)	(8)
90*	135.1	(38)	229.9	(40)	(22)
91**	152.1	(73)	231.7	(17)	(9)

*Ewes mated at both Kamo (autumn lambing) and Ruakura (spring lambing)
**All ewes mated at Ruakura (single sire mating commenced 1.12.90)

The mean BVs for each age group and their mean lambing date in 1991 are presented in Table 5 and show differences between the low (autumn) and high (spring) BV flocks of between 0.16 and 0.28 units depending on age group. The difference in mean day of lambing between the flocks differed from age group to age group but averaged 26 days overall.

TABLE 5 Distribution of BVs and lambing performance for the 1991 matings

Year born	Flock	no	Mean BV	Mean day of lambing
1985	A	13	-.107	158
	S	13	+.129	205
1986	A	11	-.080	145
	S	12	+.198	235
1987	A	19	-.199	155
	S	19	-.003	155
1988	A	49	-.109	175
	S	52	+.074	208
1989	A	35	-.132	169
	S	35	+.029	180
Total	A	127	-.126	167
	S	131	+.068	193

DISCUSSION

There are very few reports of the genetic parameters of date of lambing. The estimate of heritability for standardised lambing date (0.23) in this report is similar to the estimates of Fahmy (1990) of 0.17 from regression of daughter on dam and 0.25 from sire and dam components of variance. It is also similar to the estimate of Thrift *et al.*, (1971) of 0.24 for Southdown sheep. One would normally expect heritability on the transformed (underlying) scale to be greater than that estimated on the actual scale. However, the estimate of 0.31 for actual lambing date can not be directly compared since the data sets are not equivalent. Ewes which failed to lamb in a particular year had missing data on the actual scale and were assigned an arbitary value when calculating the standardised lambing date.

These heritability estimates are also in the range of those reported for date of onset of breeding season which have been summarised by Hanrahan and Quirke (1986). By contrast the estimate of heritability for litter size 0.03 is at the lower end of the range of estimates that have been reported for this trait in different breeds (Turner, 1969; Fahmy, 1990) and is very similar to that reported by Ch'ang and Rae (1970). The effect of age (parity) on mean date of lambing seen in the present analysis is in agreement with those reported by Thrift *et al.*, (1971) and Fahmy (1990).

The repeatability estimates of 0.36 for standardised and 0.43 for actual lambing date in the present report are slightly higher than those reported by Fahmy (1990) and are in the range of those reported for date of onset of breeding season (Hanrahan and Quirke, 1986). The estimate of repeatability 0.36 for standardised date of lambing in the present report suggests that selection on the basis of 3 lambing records would be about 30% more accurate than selection on the basis of a single record.

The estimates of correlation between litter size and date of lambing indicate little or no relationship between the two traits. This differs slightly from the negative relationships reported by Fahmy (1990). While a negative phenotypic relationship can be partially explained by the generally lower ovulation rate recorded at the first cycle of the breeding season, the lack of a negative genetic correlation is welcomed in the context of selection for out-of-season lambing.

Until 1990 all selection in the Kamo flock was in one direction for earlier lambing and no control or divergent selection lines were maintained. The relationship between actual lambing performance and the BV estimations in 1991 showed an overall difference of 0.19 BV units and 26 days in lambing date. Examination of the age of ewe (year born) effect indicates a wider difference in lambing date between the autumn (- ve BV) and spring (+ ve) flocks for the older ewes which reflects the greater reliability of their BV estimations due to the higher number of individual performance records. The greater difference in the mean BV for the flocks is also a reflection of the more accurate selection that was able to be performed on the basis of the ewes own performance compared to that which relied on the dam performance only in the younger age groups.

Calculation of BVs has enabled selection lines in both directions to be established. These are being utilised to determine what physiological and endocrinological mechanisms have been changed by the selection process. Are the autumn lambing ewes less sensitive to the controlling effects of day length or have they become more sensitive to effects of ram introduction? Has selection for early lambing altered any other parameters such as rate of testis growth, age at puberty etc that may be used as early selection indicator traits in the young animal?

The moderate to reasonably high heritability and repeatability reported in this paper indicate that reasonable progress could be made in the development of an out-of-season breeding flock. Given the selection differential applied to this flock (5% of male 25% of female) and using data based on 3 lambing records of the dam then the percentage of autumn lambing ewes would be expected to increase by 3-4% per year. However this rate would be modified by a number of factors including the proportion of autumn breeders already in the flock.

ACKNOWLEDGEMENTS

To Lynne D. Wilson and Catherine A. Cammeron for the development and maintenance of the data base, and to A.G. Monigatti for management of flock and collection of records at Kamo.

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