GENETIC PARAMETERS FOR REPRODUCTION IN SHEEP

N.M,. FOGARTY*+, G.E. DICKERSON* and L. D. YOUNG*

SUMMARY

Data were analysed from 4219 ewes, representing 412 sires, with a total of 10959 joining records, over four years. The ewes comprised five pure breeds and various generations of crosses, involved in development of two composite maternal lines, joined under an 8-monthly lambing regimen. Heritability, repeatability and genetic and phenotypic, correlations were estimated for total number and weight of lamb weaned per ewe joined as well as each component trait i.e. fertility, litter size, neonatal and postnatal lamb survival and weaning weight. Heritability was low for each trait and ranged from .02 to .ll based on single individual records and .06 to .16 for the mean of repeated records. The results highlight the importance of fertility and lamb survival, as well as other component traits, in phenotypic and genetic variation for overall lamb production under the accelerated lambing regimen existing during the study.

INTRODUCTION

The proportion of total production costs accounted for by replacement and maintenance of the breeding female is much higher for sheep and beef cattle than for the other meat producing species (Dickerson 1978), mainly because of their relatively low reproductive rate. For sheep, Dickerson (1978) has shown that, at least when wool is not important, there is a much greater potential for increase in both biological and economic efficiency through genetic improvement in reproductive rate than in growth rate or body'composition. Reproductive rate, defined as number (and weight) of lambs weaned per ewe joined is dependent on various components, namely fertility, litter size, neonatal and postnatal lamb survival (and lamb growth). The development of efficient selection programs depends on a knowledge of heritability and variation as well as phenotypic and genetic correlations between the various component traits. This paper reports parameter estimates obtained from sheep involved in a maternal breed development project under accelerated lambings over four years at the Roman L. Hruska Meat Animal Research Centre, Clay Center, U.S.A.

MATERIALS AND METHODS

The sheep comprised five pure breeds, Suffolk (S), Rambouillet (R), Dorset (D), Targhee (T), and Finnsheep (F) and various generation crosses in the formation of two composite lines ($C1=\frac{1}{2}F\frac{1}{4}R\frac{1}{4}D$ and $C2=\frac{1}{2}F\frac{1}{4}S\frac{1}{4}T$). The data were from 4,219 ewes, representing the progeny of 412 known sires, with a total of 10,959 joining records. Ewes were joined to lamb at 8-monthly intervals in January, May and September of 1976 to 1979 and some groups at 12-monthly intervals to lamb in April 1978 and 1979. Ewes were first joined to lamb at 12 or 16 months of age. The average number of ewe joining records was 2.6 (range 1 to 8), and the average ewe joining age was 2.3 years. All healthy ewe lambs without gross abnormalities were retained for breeding. Ram lambs were selected from multiple births on the basis of weight adjusted for age, rearing type and age of dam, with sire lines maintained.

---

* Roman L. Hruska Meat Animal Research Center, Clay Center, Nebr., U.S.A.

+ Current address: Agricultural Research Station, Cowra, N.S.W. 2794

For each ewe joined to lamb in a given year/season the number of lambs weaned and weight of lamb weaned were defined. Weaker lambs in excess of two per ewe, and lambs that were not or could not be mothered by their dam, were artifically reared in a nursery. These lambs were included in the data in this paper. These two composite traits comprise the following component traits for the ewe:

- fertility
- litter size
- neonatal lamb survival (to one day)
- postnatal lamb survival (one day to weaning)
- mean lamb weaning weight (adjusted to 42 days of age and ram lamb equivalents).

Performance was standardised in order to compare ewes with different joining sequences of seasons and years, different lambing/joining intervals, and to account for vastly different levels of performance at the various lambing seasons, especially for fertility. The traits defined above for each ewe were adjusted to a three-year-old ewe equivalent, using linear and quadratic age regressions. Deviations of individual ewe age adjusted traits from year/season means were expressed in standard deviation units to standardise traits across year/seasons.

Nested analyses of variance were used to obtain half-sib estimates of heritability for individual records of standardised traits. Estimates of heritability were similarly obtained for the mean of repeated ewe records of standardised traits. Repeatability was estimated by intraclass correlation and by the regression of subsequent on earlier parity performance for standardised traits, pooled over three parities. Genetic and phenotypic correlations were obtained between mean record traits, as correlations between individual records for the non independanttraits would have little meaning.

RESULTS AND DISCUSSION

Repeatability estimates for the various traits (Table 1) are low, but within the range found in the literature. The lower intraclass correlation than pooled regression estimates of repeatability for fertility, litter size and composite traits are probably due to differences in scale between the various parity records. This would result in a pseudo ewe x parity interaction and reduce the intraclass correlation. Heritability estimates for individual records are low, although more than twice their standard error for most traits. The estimates for fertility and litter size are within the range of literature estimates but few if any other estimates are available for neonatal and postnatal survival, mean lamb weaning weight and total weight of lamb weaned per ewe joined. The considerably higher heritability for mean ewe record (Table 1) is expected and illustrates the desirability of having repeated ewe records to obtain more accurate estimates of breeding value for reproductive traits.

Phenotypic correlations between mean fertility and the other component traits were close to zero, but higher (r_p=.6) with number and weight of lamb weaned, (Table 2). Litter size was negatively correlated with lamb survival and mean weaning weight, but positively with number and weight of lamb weaned as would be expected. Both number and weight of lamb weaned are moderately correlated with neonatal (r_p=.3) and postnatal (r_p=.6) survival.

Genetic correlations (Table 2) had relatively high standard errors and their magnitude fluctuated widely because of low genetic variance for some traits. Litter size was negatively genetically correlated with fertility, lamb survival and mean weaning weight (not significant). Genetic correlations between weight of lamb weaned and the components fertility, lamb survival and mean weaning weight were moderate and positive.

TABLE 1 Repeatability and paternal half-sib heritability estimates (SE)

	Repeatability				Heritability			
	Intraclass correlation		Pooled regression		Individual record		Mean record	
	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE
Component traits								
Fertility	.06	.01	.09	.02	.06	.02	.09	.05
Litter size	.08	.02	.16	.03	.11	.04	.16	.06
Neonatal survival	.15	.02	.03	.02	.02	.04	.10	.06
Postnatal survival	.11	.02	.02	.02	.07	.04	.15	.06
Mean weight	.13	.03	.10	.03	.10	.05	.13	.07
Composite traits (per ewe joined)								
Lambs weaned	.05	.01	.12	.02	.03	.02	.06	.05
Weight weaned	.05	.01	.12	.02	.06	.02	.15	.05

TABLE 2 Phenotypic (above diagonal) and-genetic (below diagonal) correlations (± se.)- between mean record traits.

	Fertility	Litter size	Neonatal survival	Postnatal survival	Mean weight	Lambs weaned*	Weight weaned*
Fertility		.03 (.02)	.03 (.02)	- .02 (.02)	- .01 (.02)	.61 (.01)	.61 (.01)
Litter size	- .34 (.28)		- .15 (.02)	- .20 (.02)	- .38 (.02)	.26 (.02)	.13 (.02)
Neonatal survival	- .22 (.35)	- .30 (.32)		.08 (.02)	.06 (.02)	.34 (.02)	.35 (.02)
Postnatal survival	- .09 (.30)	- .32 (.28)	.78 (.52)		.16 (.02)	.55 (.01)	.58 (.01)
Mean weight	.18 (.33)	- .39 (.24)	1.42 (2.04)	- .26 (.82)		- .14 (.02)	.23 (.02)
Lambs weaned*	.30 (.44)	.04 (.40)	.68 (.41)	1.60 (1.30)	0		.94 (.00)
Weight weaned*	.58 (.21)	- .02 (.27)	.49 (.28)	.91 (.17)	.41 (.44)	1.05 (.11)	

* per ewe joined

Path coefficient methodology (Dickerson 1969) was used to determine the standard partial regression coefficients for the composite (i.e. dependent) triats, number and weight of lamb weaned, on each of the component (i.e. dependent) traits for both genetic and phenotypic effects. These standard partial regression coefficients (Table 3) measure the direct linear change, in standard deviation units, of the dependent trait (i.e. number or weight of lamb weaned) per unit change in each component trait, while holding all other component traits constant. The squared regression coefficients indicate the relative importance of the various component traits to the composite trait.

TABLE 3 Standard partial regression coefficients for weight and number of lambs weaned (per ewe joined) on the component traits.

Component trait	Weight weaned		Lambs weaned	
	Genetic	Phenotypic	Genetic	Phenotypic
Fertility	1.029	.606	.588	.607
Litter size	.668	.384	.792	.287
Neonatal survival	.596	.325	-1.144	.325
Postnatal survival	.712	.597	2.799	.621
Mean weight	- .172	.269	-	-

The generally larger and more variable values of the standard partial regressions using the genetic rather than the phenotypic correlations reflects the lower precision associated with the estimates of genetic correlations. However the relative values of the standard partials for each of the component traits is similar for genetic and phenotypic contributions.

These results highlight the importance of considering postnatal survival and fertility, as well as the other components, in selection programs aimed at increasing reproduction. Past recommendations have emphasised selection for litter size in preference to composite traits or an index, because heritability estimates for litter size have tended to be higher, little permanent benefit has been predicted from culling dry ewes and because of simplicity (e.g. Turner and Young 1969). Often little variation is expressed for fertility and lamb survival as performance is near the upper limit of one or can be improved by non-genetic means. However under accelerated lambing regimens, where at least some joinings occur in seasons of reduced estrous activity, genetic variation for fertility can be expressed. In this study fertility was low, as most ewe joinings were early or late in the breeding season, or in the anestrous season, under an accelerated lambing regimen. Hence variability was expressed for fertility and this component was an important source of genetic and phenotypic variation in overall reproductive rate, Similarly lamb survival was low throughout the study and the increased variability contributed markedly to the variation in overall reproductive rate.

These results further point out the possible importance of genotype x environment interactions, not only between different geographical areas, but between different management situations. Optimum selection indexes may have quite different weightings for an annual spring lambing flock than for a flock under an accelerated lambing system. It is also important that flocks be monitored regularly so that changes in the environment which bring about changes in importance of index components can be taken into account.

REFERENCES

DICKERSON, G.E. (1969). In "Techniques and Procedures in Animal Science Research" (Am. Soc. Anim. Sci. : Albany, N.Y.).

DICKERSON, G.E. (1978). Anim. Prod. 27: 367.

TURNER, H.N., and YOUNG, S.S.Y. (1969). "Quantitative Genetics in Sheep Breeding" (MacMillan : Melbourne).