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Impact of early age litter size on subsequent litter output in ewes

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ABSTRACT

Data from 28 performance recorded sheep flocks were evaluated to test for effects of litter size early in a ewe's life, on subsequent litter sizes. Ewes lambing twins at 2, 3 or 4 years of age had litters with on average 0.04 to 0.08 more lambs at each subsequent lambing than ewes lambing singles. The corresponding increases for ewes lambing triplets versus singles ranged from 0.23 to 0.26, with retention of the effect through successive litters. When data were adjusted to account for a ewe's lifetime genetic potential for prolificacy, evidence for an antagonistic environmental effect on litter size following a previous large litter was identified. This effect was approximately twice as high for triplets relative to singles (-0.19 to -0.32) when compared with twins relative to singles (-0.09 to -0.18), and declined in its effect on lambings more than one year later. It suggests that preferential treatment of ewes based on their previous lambing performance might improve their subsequent lambing performance. Culling two tooth ewes based on a single lambing record is unlikely to be economically viable, but there may be situations where reduced flushing of two tooth ewes prior to mating might be justified in prolific commercial flocks. The power and limitations of using data from performance recorded flocks to make recommendations relating to management decisions in commercial flocks is discussed.

Keywords : Prolificacy; sheep; survival; productivity.

INTRODUCTION

While the primary motivation for intensively recording ewe reproductive performance in sheep flocks is for identification of elite breeding candidates, analysis of this data to quantify the extent of environmental influences on traits is also of value. Studies by, for example, Jury *et al.* (1979), Johnson *et al.* (1980) and Newman *et al.* (1983) have used data from commercial sheep breeders to evaluate the degree to which their means and variances are affected by factors such as breed, flock, sex, age of dam, and birth-rearing rank. The primary motivation for these studies was to enhance correction factors in genetic evaluation systems. More recently, Nicoll *et al.* (1999) used sheep breeder flock records to evaluate the extent of lamb mortality between recording events from scanning to weaning. Their study was motivated by the need to identify where appropriate management strategies could be applied to reduce reproductive wastage.

Recent increases in ewe sheep flock productivity are raising concerns in the industry about highly prolific ewes 'burning out' and either dying or being culled at relatively young ages. Because number of lambs born per ewe lambing is recorded in substantial detail by a large number of New Zealand sheep breeders, an opportunity may exist to evaluate evidence for or against stress placed on ewes having high litter sizes early in their reproductive lifetime. The objective of this paper was to investigate the subsequent reproductive performance of ewes having high litter sizes at early lambings. Furthermore, we formulate and investigate a hypothesis that opposing forces exist with a genetic drive for ongoing high prolificacy working directly against the stresses placed on the ewe from high litter sizes early in life.

MATERIALS AND METHODS

Data

Data from 28 performance recorded sheep breeding flocks were used. Performance recording was carried out in these flocks with the primary purpose of obtaining accurate genetic evaluations for a wide range of traits including number of lambs born per ewe lambing. The primary breeds of the flocks could be broadly classified into Romney, Coopworth and Composite, with the composite breeds having been constructed from a wide range of parent breeds with quite different composition across flocks.

Participating flocks were geographically located over a wide range of environments, with the majority being based in the South Island. In general, these flocks had higher lambing percentages than average for performance recorded flocks in New Zealand, and substantially higher lambing percentages than the average commercial flock in New Zealand.

Data files containing flock code, birth year, birth rearing rank, age of dam, birthday and numbers of lambs born from 2 to 5 years of age for ewes born between 1988 and 2003 were obtained from Sheep Improvement Limited for flocks that provided written permission for access to their data. The most recent estimated breeding values for number of lambs born per ewe lambing calculated by Sheep Improvement Limited for each ewe were also obtained.

Statistical analysis

Data were analysed using PROC GLM of SAS with a standard set of fixed effects fitted in each model on a flock by flock basis. This standard set of fixed effects (corresponding to the ewes) was made up of year of birth, birth rearing rank, age of dam, birth day of the year, and year of birth. The dependent variable was number of lambs born (NLB) by the ewe at either 3, 4 or 5 years of age. Litter sizes of 0 were set to missing. For NLB at 3yo, NLB at 2yo was fitted as an additional independent variable and Least Squares Means (LSM) were computed for 3yo litter size for ewes having had single, twin and triplet litters as a 2yo. For NLB at 4yo, NLB at 2yo and 3yo were fitted and LSM estimated in additional analyses, and for NLB at 5yo, NLB at 2yo, 3yo and 4yo were fitted in separate analyses. The above models were then repeated, with the most recent estimate of the ewes NLB estimated breeding value fitted as an additional covariate.

LSM solutions for previous litter sizes of twins and triplets were then expressed as a difference from the LSM for singles. These were computed on a flock by flock basis, and a weighted average taken across all flocks. The weighting factor used was the standard error of the difference between LSM. A count of how many flocks in each analysis that showed significant differences between LSM, and also the number of differences between LSM that were of atypical sign, were kept. Least squares means were obtained for ewes with quadruplet litters in their previous lambing, but these results are not reported because of low numbers of ewes.

Flocks with less than 100 ewes lambing at both the affected age, and the previous age being investigated, were omitted from the corresponding analysis. After all data edits, 100,415, 66,385, 42,023, 69,011, 43,681 and 44,273 ewes across all flocks with NLB records at 2yo and 3yo, 2yo and 4yo, 2yo and 5yo, 3yo and 4yo, 3yo and 5yo, and 4yo and 5yo, respectively.

RESULTS

Table 1 shows the effects of higher litter size at earlier lambings on realised litter sizes at subsequent lambings. In all cases, ewes with a higher NLB at a previous lambing are expected to have a higher NLB subsequently, when considered across all flocks. Notably though, the increases in subsequent litter sizes on average are very small for ewes lambing twins versus ewes lambing singles in a previous litter, and there are many flocks where the effect is non significant and/or reversed in sign. For ewes lambing triplets versus ewes lambing singles in a previous litter, the increase in subsequent average litter size remained very consistent across age group. The effect of lambing triplets as a 4yo on the following litter was slightly lower than the effect of having triplets at 2yo and 3yo on their following litters.

Table 2 shows the effects of higher litter size at lambing on realised litter sizes at subsequent lambings after a correction factor has been fitted for the inherent genetic prolificacy of the ewes. Results in Table 2 show a strong antagonistic or negative carryover environmental effect of a high litter size in an earlier lambing on subsequent lambings. The effects for twins versus singles in Table 2 are approximately half the magnitude, on average, of the effects of triplets versus singles at the previous lambing.

When assessed visually, there were no clear systematic effects of breed of flock, or geographic region on the estimates obtained.

DISCUSSION

The data reported in this study (Table 1) suggests that ewes with triplet litters early in life are a much better prospect for predicting high lifetime NLB than ewes with twin litters. Fluctuations in ewe condition over years affecting ovulation rate (*e.g*. Coop, 1962, Rattray *et al.,* 1980) and random embryonic mortality (*e.g*. Meyer *et al.,* 1983) are well known environmental factors likely to interrupt the genetic drive for consistent lifetime lambing performance. However, one might still have expected that having twins at a previous litter would, on average, result in one half of the future litter size increases relative to what we have observed for ewes having triplets in a previous litter. Thus, the data imply that having singles versus twins is much less repeatable than having triplets versus twins. This result is disappointing from a practical livestock production perspective, because triplet litters are not nearly as economically superior over twin litters, when compared with the superiority of twin litters over single litters (*e.g*. Amer *et al.,* 1998; Morel & Kenyon, 2006). Ewes lambing triplets are often scarce and it is highly unlikely to be cost effective

Table 1: Summary of estimates of flock specific effect of litter size at previous lambing on current litter size.

Affected lambing	Litter size contrast	Effect[1]	Prev lambing as 2yo	Prev lambing as 3yo	Prev lambing as 4yo
3yo	2 vs. 1	Mean	.068	-	-
		Std. Dev.	.051	-	-
		Flocks	28	-	-
		Sig. flocks	18	-	-
		Reverse	3	-	-
	3 *vs*. 1	Mean	.238	-	-
		Std. Dev.	.215	-	-
		Flocks	28	-	-
		Sig. flocks	20	-	-
		Reverse	1	-	-
4yo	2 *vs*. 1	Mean	.063	.047	-
		Std. Dev.	.048	.086	-
		Flocks	28	28	-
		Sig. flocks	12	11	-
		Reverse	2	4	-
	3 *vs*. 1	Mean	.263	.237	-
		Std. Dev.	.104	.276	-
		Flocks	28	28	-
		Sig. flocks	21	23	-
		Reverse	0	1	-
5yo	2 *vs*. 1	Mean	.077	.058	.037
		Std. Dev.	.071	.069	.060
		Flocks	28	28	28
		Sig. flocks	9	7	4
		Reverse	6	5	7
	3 *vs*. 1	Mean	.226	.253	.215
		Std. Dev.	.170	.187	.123
		Flocks	27	28	28
		Sig. flocks	14	20	18
		Reverse	2	0	1

[1]Mean=weighted mean of within flock estimates, Std. Dev.=standard deviation (unweighted) of within flock estimates, Flocks=number of flocks meeting the criteria to estimate the contrast, Sig. Flocks=number of flocks where the corresponding Least Squares Means (LSM) for the contrasts of previous litter size effects were significantly different from each other, Reverse=number of flocks where the sign of the estimated difference between corresponding LSMs was negative.

Table 2: Summary of estimates of flock specific effects of litter size at previous lambing on current litter size after adjustment for NLB breeding values.

Affected lambing	Litter size contrast	Effect[1]	Prev lambing as 2yo	Prev lambing as 3yo	Prev lambing as 4yo
3yo	2 *vs*. 1	Mean	-.180	-	-
		Std Dev	.055	-	-
		Sig. flocks	27	-	-
		Reverse	0	-	-
	3 *vs*. 1	Mean	-.316	-	-
		Std Dev	.159	-	-
		Sig. flocks	27	-	-
		Reverse	0	-	-
4yo	2 *vs*. 1	Mean	-.127	-.139	-
		Std Dev	.040	.032	-
		Sig. flocks	22	23	-
		Reverse	0	0	-
	3 *vs*. 1	Mean	-.224	-.246	-
		Std Dev	.099	.090	-
		Sig. flocks	20	25	-
		Reverse	0	0	-
5yo	2 *vs*. 1	Mean	-.090	-.098	-.128
		Std Dev	.058	.070	.043
		Sig. flocks	16	12	21
		Reverse	0	2	0
	3 *vs*. 1	Mean	-.222	-.187	-.232
		Std Dev	.158	.105	.137
		Sig. flocks	20	14	23
		Reverse	0	1	1

[1]See Table 1 for explanation of Effect abbreviations.

to cull ewes at weaning that had scanned twins previously. Our data suggest that there would be minimal benefits from culling ewes observed to have had singles at one pregnancy scanning. The benefits would certainly be insufficient to justify the costs of increased replacements. With cost and operationally effective individual animal electronic ID systems likely to come available in the near future, it would be worthwhile to use this data to evaluate culling policies based on sequences of scanning records over years.

If it can be accepted that fitting NLB estimated breeding value is effective as a correction factor for a ewe's inherent genetic drive to maintain a certain level of prolificacy, then the negative effects of high previous litter size on subsequent litter size described in Table 2 provide evidence for an antagonistic environmental carryover influence from one litter to the next. In other words, if we compare two genetically identical ewes, but one, by chance, has singles in a previous litter and the other triplets, then on average, we would expect a higher subsequent lifetime litter output from the ewe that had singles. However, on average, the effects shown in Table 2 suggest that the total lifetime lamb production would not be higher for a 2yo ewe lambing a single, relatively to a genetically identical 2yo ewe lambing a triplet. The increases over an average of 2 subsequent litters in a lifetime (about 0.5 of a lamb from Table 2) would not compensate for the 2 extra lambs initially, unless two tooth ewes lambing triplets were substantially less valuable than two tooth ewes lambing twins.

There are several potential practical farm implications from the existence of the antagonistic environmental carryover effects between successive litters. Firstly, it implies that preferential treatment of ewes based on their previous litter size at scanning might improve their performance at subsequent lambings. In fact, it is possible that the variation across flocks in the data reported here may in part reflect differences in preferential treatment by the various flock managers. Secondly, commercial flock managers with very prolific ewes might seek to limit the flushing of two tooth ewes at mating, and possibly even nutritionally restricting them, with a view to limiting the numbers having triplets. It should be noted though, that for prolific flocks such an approach generally results in less triplet and more single bearing ewes, rather than an increase in the proportion bearing twins. Care would also be required to ensure that lighter weights at joining did not carry through to become lighter weights in late pregnancy and lactation. The economics of any such policy are likely to be most favourable when twin bearing ewes are of comparable profitability to triplet bearing ewes at 2yo, but less profitable at later ages. In contrast, the carryover effects from management factors that increase prolificacy of older ewes will be much less, because they have a shorter remaining life.

Carryover effects of high early litter sizes on ewe survival should be an important additional consideration in the formulation of management policies to address industry problems of ewe burn-out. Unfortunately, data from recorded sheep breeder flocks is not necessarily appropriate for assessing the effects of early litter size on ewe longevity in a commercial flock context. Culling decisions in breeder flocks may be based on strategies to increase the genetic merit of the flock. As such, ewes that have had singles as a two tooth might have a long and productive lifetime in front of them, but they may be culled because of having low predicted genetic merit for NLB, which is commonly an economically influential genetic trait in sheep selection indexes. Such biases are not a problem when NLB in the subsequent litter is the independent variable in the analysis as in the data we describe here.

There is some scope to doubt the validity of fitting NLB estimated breeding value as a correction factor to allow partitioning of genetic and environmental carryover effects. Ideally, the correction factor should be completely independent of the dependent variable. In general, we found correlations typically within the range of 0.4 to 0.6 (results not shown) between individual litter size records, and a ewe's most recent estimated breeding value for NLB. For this reason, we attempted an additional analysis (results not shown) looking at the effect of 2yo litter size on 3yo litter size, where we restricted the data to only ewes that had twins at both 4years of age, and again at 5 years of age. There were insufficient numbers to observe the effects of 2yo ewes having triplets, but 2yo ewes having twins in this restricted data had smaller subsequent litters than 2yo ewes having singles in the 10 flocks where there was enough data for a statistically significant effect to be observed. This subsequent analysis does provide some additional support for the existence of an antagonistic environmental carryover effect running opposite to a ewe's inherent genetic drive for prolificacy.

While there are some limitations from using data from performance recorded sheep flocks, this study has demonstrated substantial statistical power for obtaining information that might be useful in guiding specific culling and management decisions by commercial farmers. This power arises at relatively low cost and is due to the large number of records available over many years and from many flocks. The fact that quite significant variation across flocks exists in the estimates in Tables 1 and 2 poses a question about the general reliability of equivalent results that might be obtained from a single experimental flock over a handful of years. However, there is still an important role for experimental flocks. Firstly, to facilitate more detailed study of causal components to the results observed here, and secondly, to deal with situations where the unique decisions made by stud breeders bias results in a way that is not consistent with the decision processes of commercial sheep farmers.

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REFERENCES

Amer, P.R.; McEwan, J.C.; Dodds, K.G.; Davis, G.H. 1998: Economic values for ewe prolificacy and lamb survival in New Zealand. *Livestock Production Science* **58**: 75-90.

Coop, I.E. 1962: Liveweight-productivity relationships in sheep. *New Zealand Journal of Agricultural Research* **5**: 249-264.

Johnson, D.L.; Clarke, J.N.; Robinson, C.A. 1980: Liveweight Variation in Sheeplan Flocks. *Proceedings of the NZ Society of Animal Production* **40**: 254-257.

Jury, K.E.; Johnson, D.L.; Clarke, J.N. 1979: Adjustment factors for lamb weaning weight. I. Estimates from commercial flocks. *New Zealand Journal of Agricultural Research* **22**: 385-389.

Meyer, H.H.; Clarke, J.N.; Harvey, T.G.; Malthus, I.C. 1983: Genetic variation in uterine efficiency and differential responses to increased ovulation rate in sheep. *Proceedings of the NZ Society of Animal Production* **43**: 201-204.

Morel, P.C.H.; Kenyon, P.R. 2006: Sensitivity analysis of weaner lamb production in New Zealand. *Proceedings of the NZ Society of Animal Production* **66**: 377-381.

Newman, S.-A.N.; Wickham. G.A.; Rae, A.L.; Anderson, R.D. 1983: "Weaning weight adjustments for selecting lambs born to year-old ewes. *New Zealand Journal of Agricultural Research* **26**: 427-431.

Nicoll, G.B.; Dodds, K.G.; Alderton, M.J. 1999: Field data analysis of lamb survival and mortality rates occurring between pregnancy scanning and weaning. *Proceedings of the New Zealand Society of Animal Production* **59**: 98-110.

Rattray, P.V.; Jagusch, K.T.; Smith, J.F.; Winn, G.W.; MacLean, K.S. 1980: Flushing responses from heavy and light ewes. *Proceedings of the New Zealand Society of Animal Production* **40**: 34-37.