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Recognising the limits to live weight-reproduction relationships in ewes

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ABSTRACT

The relationship between joining live weight and ovulation rate and number of lambs born was examined in a composite flock of small- and large-framed ewes. Approximately equal numbers of small- (n = 315) and large (n = 305) framed, mixed-age ewes of equal average condition score, selected in the same proportion from 9 commercial flocks (mainly Coopworth), were managed together from early March to pre-lambing. The average pre-joining live weight (±SD) of small-framed ewes (61.3 ±6.35 kg). was significantly (P<0.001) lower than that of large-framed ewes (71.1±6.58 kg). Ewes were joined with 14 Coopworth ram hoggets fitted with ram harnesses on 8 April. Ewes marked by rams were temporarily removed from the flock every 7 days for 21 days and ovulation rate (0, 1, 3, 4) recorded by laparoscopy the following day after fasting. Pregnancy status (0, 1, 2 or more) was recorded by ultrasonography on 4 July. Ewes were fully recorded at lambing. The mean ovulation rate (OR) of small-framed ewes was significantly lower (1.76, P<0.05) than that of large-framed ewes (1.92). The regression of OR on joining live weight (jLW) was significant (P<0.001) for small- ewes (OR = 0.0216 x jLW + 0.463) but there was no relationship between OR and jLW in large-framed ewes. Maximum OR (1.92) was predicted to occur at 67.5 kg jLW. The results of this study indicate an upper limit to the live weight ovulation rate relationship. Compared on the basis of equal ewe live weight per ha, OR per ha was 12% higher for small- than large-framed ewes.

Keywords: ewes; frame size; ovulation rate, joining live weight.

INTRODUCTION

The positive relationship between live weight and reproductive rate in ewes, originally reported in New Zealand by Coop (1962) and confirmed and refined by others (Hight & Jury, 1973; Smith *et al*., 1979; Rattray *et al*., 1980; Knight & Hockey, 1983; Thompson *et al*., 1990), is firmly established in practice and in practical farming literature (Geenty, 1997: Smith & Knight, 1998). It is likely that much of the increase in the national lambing percentage over the last 15 years has been mediated through increased ewe live weight (ES, 2002).

Since the decades of the 1960s and 1970s, when most of the original studies of the effect of both live weight and live weight change on ovulation rate and the subsequent lambing percentage were reported, there has been a significant positive genetic trend in both live weight and reproductive rate in some flocks (NZOSR, 2001). Consequently, it might be prudent to re-examine live weight-reproduction relationships with today's ewes.

An opportunity was taken to examine the joining live weight-reproductive rate relationship in a flock composed of small- and large-framed ewes sourced from current commercial flocks.

MATERIALS AND METHODS

A flock of ewes was established by selecting, in Jan/Feb 2001 and/or 2002, groups of around 25-38 ewes of either small- or large-framed frame size from mobs of 400-500 ewes on each of 9 farms. Ewes were phenotypically selected on frame size but groups were balanced for age and condition (recorded as an estimated GR measurement, the tissue depth over the 12th rib midway from the spine to the sternum). Flocks originated from north, mid and south Canterbury with one from Southland. Most of the source farms would be classed as intensive SI breeding and finishing farms (ES, 2002). Six flocks were Coopworth-, 2 Romney- and 1 Perendale-based. The ewes were transported to Lincoln University's Ashley Dene Pastoral Research Farm and managed together as one flock from arrival to pre-lambing 2002.

The onset of the breeding season of a proportion of the ewes (280) was monitored by harnessed, vasectomised rams (n=4) from 18 January to 4 April 2002. The raddle colour on the harness was changed weekly and the tag numbers of ewes marked by rams were recorded twice weekly and that date recorded as the start of the breeding season. Entire Coopworth harnessed rams hoggets (14) were introduced to all the ewes (620) on 8 April 2002. Ewes marked by the ram over the first 21 days of the joining period were drafted off at seven day intervals and ovulation rate (OR) was recorded by laproscopy the following day after fasting. OR was taken as the number of corpora lutea (CL) identified per ewe showing at least 1 CL. Ewes were returned to the mob after laproscopy.

Pregnancy status (0, 1, 2 or more) was determined by ultrasonography on 4 July. Non-pregnant ewes and those with a single foetus were removed and returned to their original owners. For the purposes of this report, it was assumed that single-scanned ewes gave birth to one lamb and that the survival of their single lambs was the same as that recorded for lambs of the small- and large-framed ewes retained. The remaining flock was divided into separate groups (25-40) of small- and large-framed ewes from the same source and set-stocked for lambing (10 days before the planned start of lambing, 3 September) on paddocks appropriately sub-divided to give the same live weight per/ha of small- or large-framed ewes. Ewes were fully recorded at lambing.

Treatment effects on continuous variables such as live weight, GR and date of onset of oestrus were analysed

TABLE 1: The joining live weight and GR of small- and large-framed ewes sourced from nine commercial properties in South Island.

			Small					Large				
Farm	**Location**	**Breed type**	**n**	**Joining live weight (kg)**	**(SD)**	**Joining GR (mm)**	**(SD)**	**n**	**Joining live weight (kg)**	**(SD)**	**Joining GR (mm)**	**(SD)**
B	N. Canterbury	Coopworth	41	56.5	4.5	7.2	1.5	35	66.8	5.0	8.4	1.4
DC	N. Canterbury	Coopworth	35	63.7	4.9	7.2	2.2	38	73.0	6.4	7.7	2.7
G	N. Canterbury	Romney	36	60.5	6.5	7.4	1.7	36	71.4	6.6	8.0	2.4
H	N. Canterbury	Coopworth	33	60.1	8.1	8.7	2.3	35	71.0	6.3	9.0	2.3
Hu	S. Canterbury	Coopworth	40	59.4	5.8	8.6	1.9	36	69.1	4.5	8.7	1.9
I	Mid Canterbury	Perendale	38	63.6	5.2	9.0	2.1	33	76.4	6.0	9.7	2.4
ML	Southland	Romney	16	60.1	4.3	8.2	1.5	25	69.8	6.8	8.7	2.4
M	Mid Canterbury	Coopworth	37	61.9	6.8	8.3	2.3	34	71.0	5.3	8.1	2.6
S	S. Canterbury	Coopworth	39	66.9	4.8	9.4	2.1	33	73.5	7.0	10.3	2.5
All			315	61.5	6.5	8.2	2.1	305	71.3	6.5	8.7	2.5

by analysis of variance using frame size and farm source as fixed effects. Distributions of discrete variables such as ovulation rate and number of lambs born were compared by a Chi-squared test.

RESULTS

Details of the location, breed type, mean pre-joining live weight and condition score of the small- and large-framed ewes sourced from each contributing flock are shown in Table 1. On average small-framed ewes were 10 kg lighter (P<0.001) than large-framed ewes and this difference was fairly consistent across all sources. Although the difference in average GR between small- and large-framed groups was only 0.5 mm, this was significant (P<0.001). The significant difference in live weight and GR between small- and large-framed ewes was maintained at lambing when the average live weight and GR were 66.3 (±7.1) kg and 3.2 (±1.7) mm, 71.8 (±6.0) kg and 3.4 (±2.2) mm respectively.

There was no significant difference in the cumulative proportion of ewes showing oestrus by 4 April (0.81 and 0.87 for small- and large-framed ewes respectively). However, the mean date of the first overt oestrus was 3 days (P<0.05) later (23 March) for small- than for large-framed ewes (20 March).

Measures of reproductive rate of small- and large-framed ewes are in Table 2. The overall ovulation rate (1.79) of small- ewes was significantly (P<0.05) below that of large-framed ewes (1.92). Although the number of ewes in each sub-flock was too low to give good estimates of OR, all flocks followed the same trend of a lower ovulation rate in small ewes. The difference in mean OR reflects the significantly higher (P<0.05) proportion of small ewes (0.28) with a single CL compared with that of large-framed ewes (0.17) (Figure 1).

TABLE 2: Reproductive parameters of small and large framed ewes sourced from nine commercial properties in South Island.

	Frame size		Significance of
	Small	**Large**	**Chi squared test**
Ovulation rate (CL/ewe)	1.79	1.92	<0.05
Non-pregnant/ewe joined	0.02	0.04	NS
Lambs born/ewe lambing	1.68	1.71	NS
CLs not resulting in a lamb	0.06	0.11	NS
Lambs alive/ewe lambing [1]	1.50	1.57	NS
Lamb survival	0.89	0.92	NS
Lambs alive/ewe joined	1.47	1.51	NS

[1] alive 24 h after birth

The regression of OR on joining live weight for all ewes (n = 605) was:

$$OR = 1.06\ (\pm 0.18) + 0.0119\ (\pm 0.0027)\ jLW$$

where OR = ovulation rate and jLW = joining live weight (kg). The regression and both the constant and regression coefficient were significant (P<0.001). The regression of OR on pre-joining GR was not significant. The equivalent regression for number of lambs born (NB) (P<0.001) was:

$$NB = 1.09\ (\pm 0.21) + 0.0089\ (\pm 0.0031)\ jLW$$

FIGURE 1. The distribution of ovulation rate, number of lambs born and number of lambs alive at 24 hours of small- and large-framed ewes sourced from ine commercial farms.

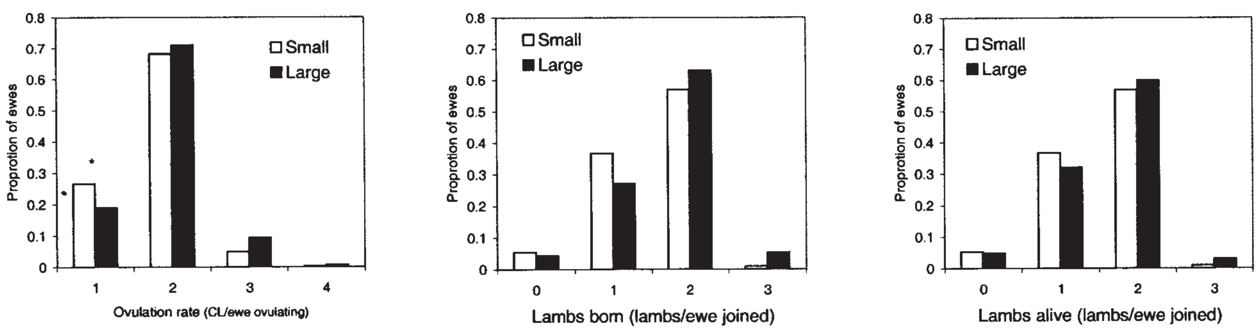
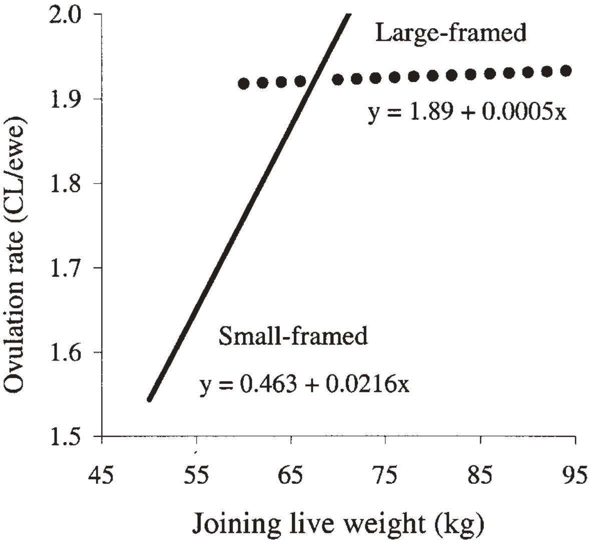


FIGURE 2: The relationship between ovulation rate and joining live weight of small- and large-framed ewes sourced from nine commercial farms.



When the data set was restricted to small ewes (n = 308), the respective regressions were (P<0.05):

OR = 0.463 (±0.28) + 0.0216 (±0.0045) jLW

and (P>0.05)

NB = 0.508 (±0.33) + 0.0187 (±0.0054) jLW

Neither of the equivalent regressions was significant when the data were restricted to large-framed ewes. Figure 2 illustrates the relationship between OR and jLW for small- and large-framed ewes. The number of ewes in each sub-flock was too small for significant regressions of OR on joining live weight, but in six out of nine flocks the regression coefficient for the small ewes was greater than that for large-framed ewes. These data suggest that the optimum joining live weight in this group of ewes was around 67.5 kg, the live weight at which the regression of OR on jLW for small-framed ewes bisects that for large-framed ewes.

There were small non-significant differences between small- and large-framed ewes in the proportion of non-pregnant ewes, the proportion of CLs not resulting in a lamb and in lamb survival (Table 2). The net result was non-significant differences of 0.04 in lambs born/ewe lambing in favour of the large-framed ewes and in the number of live lambs per ewe joined (1.47 and 1.51 respectively for small- and large-framed ewes, Figure1 and Table 2).

DISCUSSION

There are two important implications of the results of this study. First, this is the first report that clearly demonstrates a different relationship between ovulation rate and number of live lambs to increased ewe joining live weight for small- and large-framed ewes of similar condition score. Secondly, this study suggests that large-framed ewes reduce the number of lambs per given area because the relative decrease in stocking rate would be greater than the increases in OR.

The evidence presented here that there was no significant relationship between ovulation rate and live weight in large-framed ewes suggests a likely upper limit to the relationship. The within-flock change in OR per kg change in joining live weight observed in this work is compared with those previously published in New Zealand (Table 3). The mean joining live weight of ewes, even the small-framed ewes, in the current study was 5-10 kg greater than in previous studies. Thus any upper limit to the OR-jLW relationship was more likely to be detected in the present study. The inclusion of 'non-responding' large ewes in the *whole-flock* analysis diluted the effect shown with small ewes which was quantitatively similar to other reports. There is a trend in Table 3 for the predicted OR at a given jLW to increase over time. This may reflect an increase in the inherent reproductive rate of ewes over the period of 30 years.

Other studies have suggested an upper limit to the live weight-reproduction in ewes. Ducker & Boyd (1977) found no significant difference in the OR of small- and large-framed ewes (1.76 versus 1.84 for small, 64.8 kg and large, 71.0 kg ewes respectively) of the same condition score. Rhind *et al.* (1984) showed that the higher OR of very heavy, fat ewes was not reflected by a higher litter size. Coop (1962) himself recognised that the twinning/live weight relationship appeared less strong at live weights above 64 kg although he was cautious about the importance of this due to the small number of records above this live weight. A similar interpretation could

TABLE 3: Values published in NZ of the within-flock regression of ovulation rate (OR) and number of lambs born (NLB) on ewe joining live weight (kg) and the predicted values of OR and LB for a range of joining live weight.

Change per kg joining live weight OR	Change per kg joining live weight LB	Average joining live weight (kg)	Ovulation rate at 50 kg	Ovulation rate at 60 kg	Ovulation rate at 70 kg	Lambs born at 50 kg	Lambs born at 60 kg	Lambs born at 70 kg	Source
0.0005 [1]	-0.0022 [1]	71.3	1.91	1.92	1.92	1.78	1.76	1.73	Large ewes, this study
0.0119	0.0089	66.4	1.66	1.77	1.89	1.54	1.62	1.71	All ewes, this study
0.0216	0.0187	61.5	1.54	1.76	1.98	1.44	1.63	1.82	Small ewes, this study
0.0469		54.0	1.66	2.12	2.59	1.41	1.71	2.02	[2] Thompson *et al.*, 1990
0.0160		55.0	1.53	1.69	1.85	1.32	1.43	1.53	[2] Kelly & Johnstone, 1982
0.0330		50.0	1.45	1.78	2.11	1.28	1.49	1.70	[2] Knight & Hockey, 1982
	0.0156	48.0				0.90	1.05	1.21	Hight & Jury, 1979
	0.0126	55.0				0.79	0.92	1.05	Kelly, 1980
0.0208	53.0					0.80	1.01	1.22	Coop &Hayman, 1962
0.0251	56.5					0.93	1.18	1.43	Coop, 1962

[1] non-significant coefficents

[2] conversion to lambs born based on Meyer & Clark (1982)

explain the results of Rattray *et a.l* (1980) who showed that the OR of lighter (thinner) ewes increased at a higher rate with increasing live weight than that of heavier (fatter) ewes.

The optimum joining weight of around 67.5 kg identified in this study was derived in a composite flock of ewes from a number of sources and should be treated with caution in its more widespread use and needs to be confirmed for a range of genotypes. However, the practical implication is that further increases in OR of ewes over 68 kg is unlikely and efforts should be restricted to increasing the weight of lighter ewes within a flock.

The three-day later onset of the breeding season of small-framed ewes had no impact on the average lambing date of the two sub-flocks. Larger numbers of ewes would have been needed to demonstrate that the embryo loss of large-framed ewes was significant although a positive relationship between OR and partial failure of multiple ovulation has been reported (Kelly & Knight, 1980). Similarly, the difference in lamb survival between the two groups of ewes is equivocal. In a previous year, there was no difference in lamb survival of twin-born lambs from small- and large-framed ewes. The net effect of the differences in the various reproductive parameters was a relatively small (0.04) and non-significantly higher number of live lambs per ewe joined for the large-framed ewes(Table 2). Expressing LA/100 kg jLW, to adjust LA for differences in jLW between the groups of ewes, favoured the small-framed ewes (2.4 versus 2.1 LA/100 kg jLW for large-framed ewes).

The second major implication of this work is on the relative reproductivity (LA/ha) of flocks of small- or large-framed ewes. On the assumption that a comparable stocking rate of small- and large-framed ewes is 'equal live weight/ha', and using the mean pre-joining live weight (Table 1) and reproductive performance (Table 2) of small- and large-framed ewes in this study, their relative per ha production of lambs was calculated. This shows that 12% more LA/ha would be produced by small- ewes compared with large-framed ewes. In other words, the reduction of 16% in relative stocking rate of large-framed ewes was not compensated by their higher ovulation rate and lamb survival. In experiments in which stocking rate (ewes/ha) has been used to produce ewes of varying mean live weight (e.g. Rattray *et al*., 1980), the same conclusion was reached. In situations in which number of lambs/ha is limiting productivity, more smaller ewes will out-produce fewer larger ewes. This may be the case, for example, in very highly fecund flocks where any further increase in ovulation rate will lead to marked increases in the number of triple bearing ewes (Davis *et al*., 1983).

By comparing the reproductive performance of small- and large-framed ewes from a number of flocks in which the mean joining live weight was higher than in other studies, this study has indicated an upper limit to the live weight-reproductive rate relationship. When this point has been reached, further increases in the number of lambs produced/ha can only come from carrying more smaller ewes or through increased genetic potential for reproduction, or both.

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