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Studies on times of lambing in ewes grazing subterranean clover based pastures in relation to stocking rates in south-western Australia

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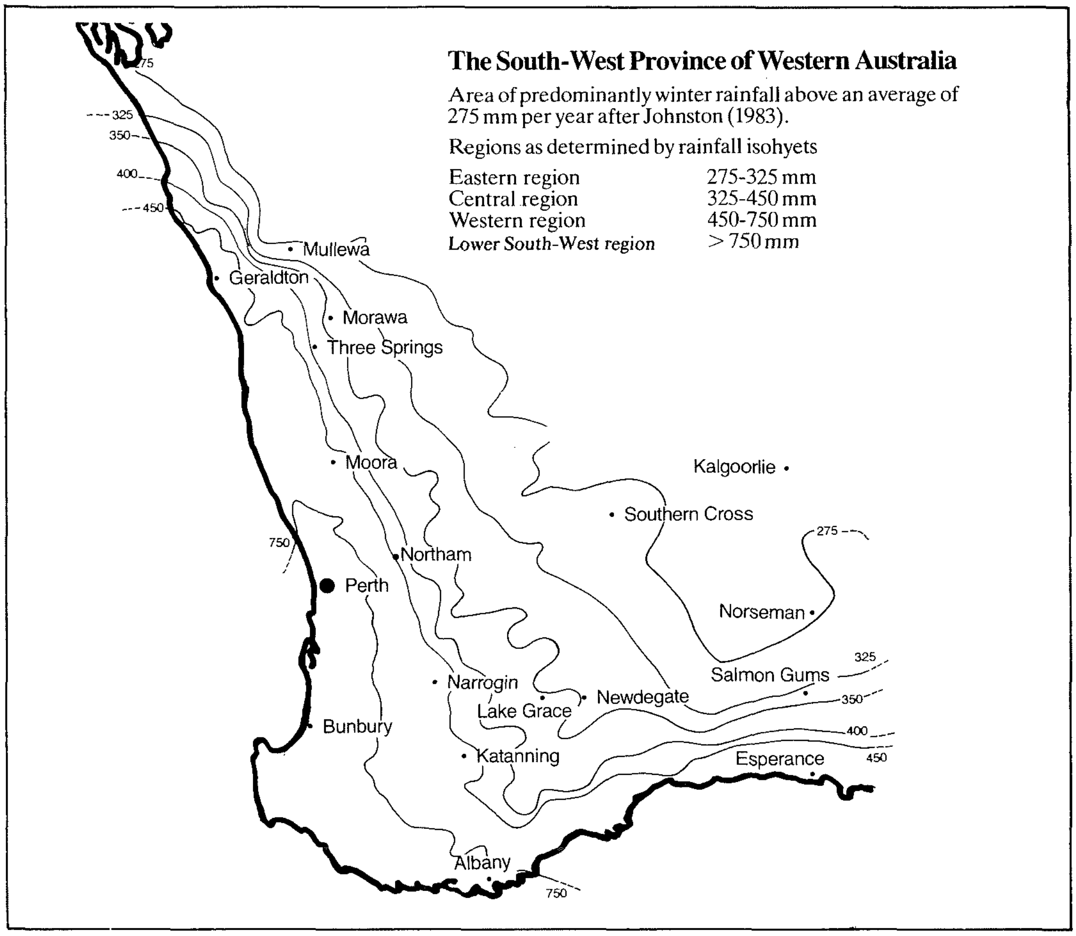
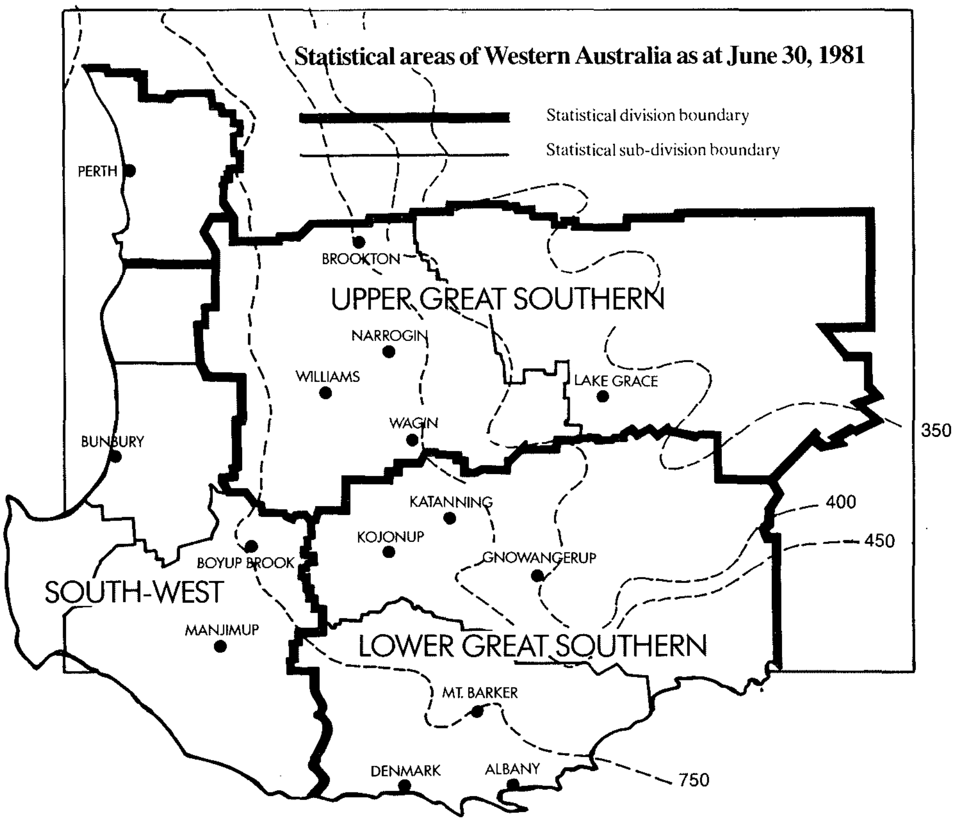

The South-West Province of Western Australia
Area of predominantly winter rainfall above an average of 275 mm per year after Johnston (1983).
Regions as determined by rainfall isohyets
Eastern region 275-325 mm
Central region 325-450 mm
Western region 450-750 mm
Lower South-West region > 750 mm
Mullewa
Geraldton
Morawa
Three Springs
Moora
Northam
Perth
Bunbury
Narrogin
Lake Grace
Newdegate
Katanning
Albany
Kalgoorlie
Southern Cross
Norseman
Salmon Gums
Esperance
275
325
350
400
450
750


Statistical areas of Western Australia as at June 30, 1981
Statistical division boundary
Statistical sub-division boundary
PERTH
BROOKTON
UPPER GREAT SOUTHERN
NARROGIN
WILLIAMS
LAKE GRACE
WAGIN
BUNBURY
KATANNING
KOJONUP
BOYUP BROOK
GNOWANGERUP
SOUTH-WEST
MANJIMUP
LOWER GREAT SOUTHERN
MT. BARKER
DENMARK
ALBANY
350
400
450
750

Abstract

This bulletin presents the results of an investigation into the effects of times of lambing and stocking rates upon sheep and pasture production in the Lower Great Southern statistical area of south-western Australia during the period 1959 to 1962. The investigation is reported in six parts.

- Effect on ewe liveweight and fertility
- Lamb losses
- Effect on lamb growth and subsequent growth after weaning
- Wool production
- Pasture production and composition
- Conclusions and practical implications

Merino ewes were grazed at three stocking rates—3.7; 7.4 and 12.4 ewes/ha over four years with the following three times of lambing.

- Autumn—April 15 to May 30
- Winter—June 15 to July 31
- Spring—August 14 to September 19

Each treatment was replicated three times with 14 ewes per plot so that there were observations on 378 ewes each year. Except for shearing, the ewes remained on the plots throughout the year.

After the first year of the experiment, ewes were culled, if they had broken mouths, following shearing. The culled ewes were replaced by ewes which had lambed at least once, and the subsequent performances of these ewes were included in the results.

It was originally intended that there be no supplementary feeding. However, two circumstances prevented this. In the autumn of 1960 and 1962, some of the sheep at 12.4 ewes/ha, lambing in the autumn, became very light in late pregnancy (< 37 kg) and they were fed an average of 226 g of concentrates/head.d for about 60 days. To overcome the extra grazing pressure by the rams, about 200 g/head.d was given during the joining period.

The sheep were medium Peppin Merinos, evenly divided into age groups of 3, 4 and 5 years which were distributed at random to the treatments. The plots were sited on land cleared from open woodland in 1952 and which had been sown to oats with 7.8 kg/ha of subterranean clover (*Trifolium subterraneum* cv. Dwalganup) in 1953. Superphosphate was applied at a rate of 202 kg/ha each year.

In nearly all years, the autumn lambing ewes at all stocking rates gained < 4.5 kg in late pregnancy. However, with winter lambing, the gains in late pregnancy of ewes stocked at 3.7 and 7.4/ha were always > 4.5 kg/head. The weight gain in late pregnancy in winter lambing ewes at 12.4/ha was sensitive to the season. In good years, there were gains > 4.5 kg whereas in poor pasture years the gains were < 4.5 kg/head. All ewes gained > 6 kg in late pregnancy when lambing in the spring.

The results show that in the absence of supplementary feeding the physiological requirements of ewes in late pregnancy are better met by spring rather than autumn lambing.

The percentage of lambs marked in this experiment was typical of the Kojonup district in the early 1960s. At the low and intermediate stocking rates the percentage of barren ewes was 29%. Increasing the stocking rate to 12.4/ha increased the proportion of barren ewes to 37%. There was no difference in the incidence of barren ewes between autumn and spring lambing (28%). However, the incidence (38%) was higher with winter lambing.

Lamb losses were increased by lambing in winter at high stocking rates. The losses (single lambs) for the three times of lambing were: autumn 19%, winter 27% and spring 17%, with most losses occurring during the first 72 hours of life. Lamb losses increased progressively with increasing stocking rate. At 3.7 ewes/ha there was 27% lamb mortality; at 7.4 ewes/ha, 29%; and at 12.4 ewes/ha, 34%.

Losses among weaner sheep were affected by both previous stocking rate and time of lambing, even though they were grazed at a relatively low stocking rate and were supplemented with oats from January until after the pasture germinated. The mortality of weaners from ewes formerly run at 3.7/ha was 8.5%; from ewes run at 7.4/ha, 10.7% and from those run at 12.4/ha, 20.3%.

Time of lambing also appeared to affect weaner mortality with the heaviest losses occurring among autumn born sheep, particularly those from the 12.4 ewes/ha plots.

There were stocking rate x time of lambing interactions upon lamb growth. The growth of autumn born lambs was always affected by stocking rate—the higher the stocking rate the lower the liveweight gain to weaning. There were no differences in liveweight gain for lambs born in winter at 3.7 and 7.4 ewes/ha, but at 12.4 ewes/ha lambs grew at a slower rate. Winter lambing always resulted in the highest individual weaning weights. Stocking rate did not significantly affect growth to eight weeks of age for lambs born in the spring. However, weaning weights for spring born lambs were never as high as those born in winter, but were often higher than those born in autumn. The combination of higher growth rate at the highest stocking rate with spring lambing resulted in the greatest liveweight gain per hectare each year.

Greasy wool production per head from ewes rearing single lambs (the numerically largest group) was 4.25 kg at 3.7 ewes/ha; 4.01 kg at 7.4 ewes/ha and 3.72 kg at 12.4 ewes/ha. Despite the reduction in wool production per head there was an increase in wool production per hectare as stocking rate increased. The highest greasy wool production per hectare was 58.1 kg from the spring lambing plots stocked at 12.4 ewes/ha.

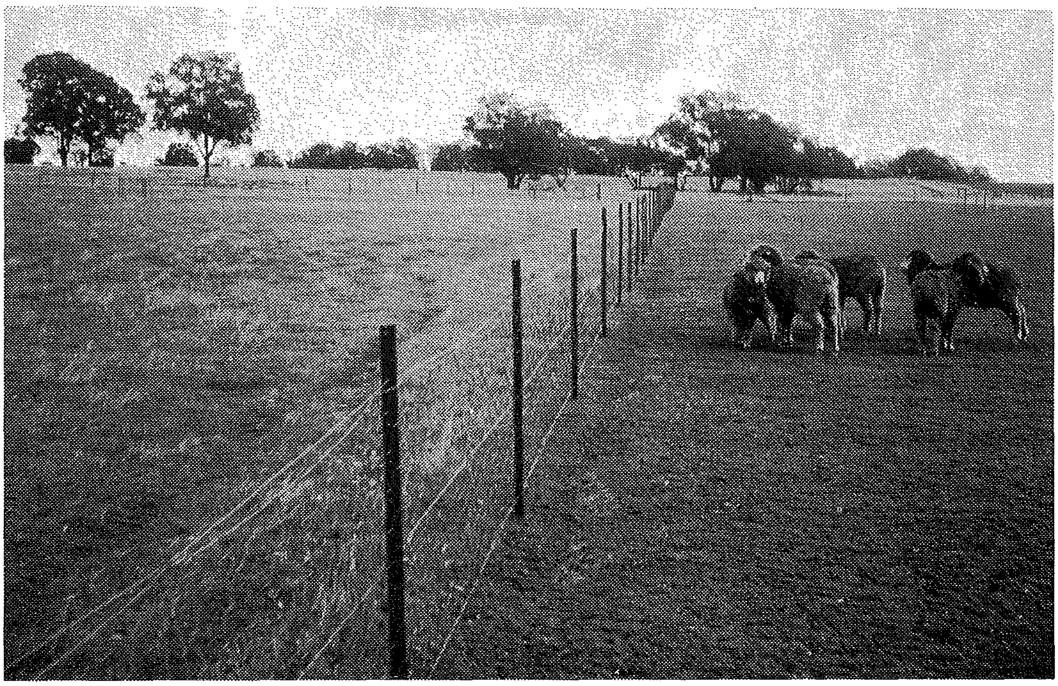
The mean amount of pasture dry matter at the end of the growing season was 3600 kg/ha with there being about 500 kg/ha in July. Increasing the stocking rate from 3.7 ewes/ha reduced the proportion of grass from 84 to 65% at 7.4 ewes/ha and 34% at 12.4 ewes/ha. This was accompanied by a

Photograph 1—Grass dominant pasture in October 1959 at the end of the growing season. Stocking rate 4.9 sheep/ha. The protected 1 m² quadrat shows the height of the ungrazed sward.

commensurate increase in the proportion of erodium (*Erodium* spp) and capeweed (*Arctotheca calendula*) with the proportion of subterranean clover remaining surprisingly constant at all stocking rates.

The two major reasons for the unsatisfactory lamb marking percentages in this experiment were ewes failing to conceive and perinatal lamb losses. It was subsequently found that most of the failure to conceive was due to the ewes being affected by subterranean clover disease.

Although fertility was low, the results showed that Merino ewes can be stocked at 7/ha in the Lower Great Southern statistical area and that more may be safely carried without recourse to supplementation provided that lambing time was changed from autumn to later in the year.



Photograph 2—Effect of grazing pressure on pasture—April 1961. Stocking rate: left—4.9 sheep/ha, right—12.4 sheep/ha.

Introduction

Two of the most important decisions made by producers that affect sheep production are when to lamb their ewes and at what stocking rate should the pastures be grazed.

Though time of lambing is clearly important, it is often difficult to achieve an appropriate compromise to give maximum sheep production. This is particularly the case in the southern areas of Western Australia with its Mediterranean climate characterised by long dry summers and mild wet winters. An autumn lambing would ensure that ewes are at their heaviest liveweight when the rams are joined which usually means greater prolificacy. However, the incidence of spontaneous multiple ovulations is highest during the months of March and April which would suggest that producers should use a spring lambing to obtain high levels of reproductive performance.

Factors, other than the ovulatory activity of the ewes and their weight at joining, which influence lambing performances include; the amount and quality of the pasture available during late pregnancy, parturition and lactation; weather conditions, e.g. temperature at joining, and rainfall and wind conditions at lambing; plus predator activity at lambing.

The most important single factor affecting sheep production per hectare is stocking rate. However, increasing stocking rate on improved pastures can have at least two concomitant harmful effects. The first is that sheep at some times of the year are inevitably at a lower plane of nutrition even if they have been stocked at a low rate, and the second is that there is sometimes an increase in legume dominance in the more heavily grazed pastures. Both of these effects can lead to a considerable reduction in sheep fertility in south-western Australia. The harmful effects of inadequate nutrition, both at joining and in late pregnancy, upon sheep are well documented, as is the effect of some strains of subterranean clover upon sheep fertility.

This Bulletin reports the effect of stocking rates and times of lambing upon sheep and lamb production, wool production and pasture production and composition during the period from February 1959 until November 1962 at Kojonup in south-western Australia.

Part 1—Effect on ewe liveweight and fertility

Summary

A factorial experiment was conducted with Peppin Merino ewes in which three times of lambing:

- Autumn—April 15 to May 30
- Winter—June 15 to July 31
- Spring—August 14 to September 19

were compared at three stocking rates (3.7, 7.4 and 12.4 ewes/ha) with three replicates of each treatment. The experiment at Kojonup, Western Australia, was conducted from February 1959 until November 1962 on pasture which had been initially sown to subterranean clover (*Trifolium subterraneum* cv. Dwalganup).

At the start of joining, the autumn lambing ewes were 2.6 kg heavier than the winter lambing ewes, and these were 5.2 kg heavier than the spring lambing ewes.

In three of the four lambings monitored, the ewes mated for autumn lambing gained < 4.5 kg in late pregnancy irrespective of stocking rate. With winter lambing, ewes gained > 4.5 kg in late pregnancy in three of the four lambings at 3.7 and 7.4 ewes/ha and gained some weight at 12.4 ewes/ha. However, at all stocking rates, ewes lambing in the spring gained > 6 kg in late pregnancy. It was concluded that the nutritional requirements of ewes in late pregnancy at Kojonup are best met under a spring lambing regime. With spring lambing in this environment, high stocking rates can be carried without recourse to supplementary feeding before lambing.

The proportion of barren ewes (29%) was unaffected when stocking rate was increased from 3.7 to 7.4 ewes/ha, but at 12.4 ewes/ha it increased to 36% ($P < 0.001$). There were no differences in the proportions of barren ewes (28%) between autumn and spring lambings. With winter lambing however, the incidence (38%) was significantly higher ($P < 0.01$). There was a higher proportion of ewes with twins in the winter lambing group (7.5% compared with 5.2% in autumn and 6.5% in spring, $P < 0.01$).

Introduction

The pattern of oestrus in relation to time of the year was studied in Western Australia by Underwood, Shier and Davenport (1944) in Border Leicester x Merino ewes and then by Oldham (1978) in Merino ewes. Underwood *et al.* (1944) showed that the incidence of oestrus was low for the first 16 d with a November-December joining.

Oldham (1978) observed that the incidence of oestrus was at a maximum in February, March and April and at its lowest in December and January. These results were not very different from those reported by Kelly (1939), Kelly and Shaw (1943), and Watson (1953) for Merinos in eastern Australia where the highest incidence of oestrus was in March, April and May and the lowest in October and November. Sinclair (1950) reported a similar pattern for maiden ewes at Trangie, New South Wales, and Thompson and Schinckel (1952) for Merinos at Roseworthy, South Australia. Schinckel (1954) showed that the first ovulation of the season is often silent, i.e. it is not accompanied by oestrus. Normal cycling has been reported for all autumn matings where oestrus observations have been reported.

The incidence of multiple ovulations is usually higher during the late summer and autumn months (Radford 1959; Hunter 1959; Dun, Ahmed and Morrant 1960; Fels, Neil, Ralph and Suiter 1969; Oldham 1978). This higher incidence of multiple ovulations has been confirmed by increased twinning percentages with autumn matings (Morley 1948; Allden 1956; McGarry and Stott 1961; Dun 1961; Reeve and Sharkey 1980).

McMeekan (1956) emphasized that stocking rate plays an important role in animal production on a "per hectare" basis. A theoretical discussion on the effect of stocking rate upon sheep production per hectare is given by Peterson, Lucas and Mott (1965). Drake and Elliott (1960), Arnold, McManus and Bush (1964), Davies and Humphries (1965), Davies and Greenwood (1972), Langlands and Bennett (1973) and

Reeve and Sharkey (1980) all showed that wool production per hectare was increased as stocking rate was increased with there being negligible effects on wool quality.

Early studies on the effect of stocking rate on the reproductive performance of Merino ewes include those of Davies (1962, 1968) and Bennett, Morley, Clark and Dudzinski (1970). These studies showed that there was initially a decline in fecundity and then a decline in fertility as stocking rate increased.

The effects of times of lambing and stocking rates upon liveweight, oestrus and fertility of Merino ewes in south-western Australia are examined in Part 1.

Materials and methods

Environment

The experiment, from February 1959 to November 1962, was on the CSIRO Division of Plant Industry Field Station, "Glen Lossie", Kojonup, Western Australia, (33°50′S, 117°09′E) where the average length of the "growing season" is 6.3 months, (Rossiter 1961). The climate is Mediterranean with the greatest incidence of rain in the winter months from May to September. Rainfall for the years of the experiment is given in table 1.

The 27 plots of the experiment included soils typical of the area. The soils were of three main types, namely, shallow lateritic podsols of low inherent fertility; truncated laterites with a thin veneer of sand over clay, and brown podsolics which are loamy sands over clay. No replicate was confined to any particular soil type.

The pastures were composed entirely of annual species having been initially sown to subterranean clover in 1953. Botanical composition, based on hand separation of cut quadrat samples, soon after the start of the experiment (July, 1959) was 66% grass, mainly *Bromus rigidus,* 17% subterranean clover *(Trifolium subterraneum* cv. Dwalganup) and 17% capeweed (*Arctotheca calendula*).

Sheep

The ewes were Peppin Merinos selected at random from the field station flock which had a previous history of autumn lambing. The selected ewes were evenly divided into 3, 4 and 5 year old groups and distributed at random within each treatment. After the first year of the experiment ewes were culled, following shearing, if they had broken mouths. The culled ewes were replaced by

Table 1

CSIRO Field Station, "Glen Lossie", Kojonup Rainfall, 1959-1962

Month	Rainfall mm				
	1959	1960	1961	1962	Long term mean
January	7	33	24	7	12
February	27	8	5	9	14
March	11	69	17	1	24
April	28	26	81	49	32
May	34	78	20	74	71
June	114	54	121	81	94
July	35	137	122	44	91
August	78	34	65	98	77
September	52	59	43	32	57
October	42	10	18	52	46
November	39	8	24	24	22
December	38	12	27	8	16
Total	508	637	548	479	556

Note: The official seasons are:
Summer—December, January, February.
Autumn—March, April, May.
Winter—June, July, August.
Spring—September, October, November.

ewes which had lambed at least once and the subsequent performances of these ewes were included in the results.

Experimental design

The experiment was a factorial design with three replications of three times of lambing and three stocking rates:

(i) Times of lambing
- Autumn—April 15 to May 30
- Winter—June 15 to July 31
- Spring—August 14 to September 19

(ii) Stocking rates (ewes/ha)
- 3.7—approximate average district stocking rate in 1959
- 7.4
- 12.4.

(iii) There were 3 replications with 14 ewes per plot giving a total of 378 ewes.

Statistical analysis

The results were collated in a form suitable for either analysis of variance or (in some instances) analysis of covariance with three replicates of a randomised block design. The independent variables were replicate, year, lambing time and stocking rate and the analysis was extended to include all first order interactions. As replicate effects were rarely significant, overall means for lambing time and stocking rate are presented in most instances. On the occasions when a significant replicate interaction did occur, this usually involved one of the high stocking rate plots and the result is presented in the text.

Differences between means were tested for statistical significance using the "Least Significant Difference" method.

Data for fertility and fecundity were examined by transforming the portions of barren monotocous and polytocous ewes to the angle whose sine is the square root of the proportions.

The relationship between liveweight at joining and fertility was examined by regression techniques where Y was the angular transformation of the proportion of either barren or lambing ewes and X was the mean liveweight.

Mating

Nine Peppin Merino rams were used, and with one or two exceptions (either mortality or an inadequate semen sample) the same nine rams were used at each time of joining in any one year. In the first year the ewes were joined with rams before being put onto the plots. For joining in subsequent years, one ram was allocated to each plot of 14 ewes. Rams were rotated at random between plots at intervals of 14 d throughout the joining period of 6 weeks.

Supplementary feeding

The amounts of supplementary feed given to avoid sheep deaths when liveweights were < 37 kg are shown in table 2.

Table 2

Supplementary feeding of sheep in poor condition

Year	Treatment	No. of days fed	Total amount fed per head kg
1960	Autumn lambing: 12.4 ewes/ha Replicate 1	59	9
	Autumn lambing: 12.4 ewes/ha Replicate 2	83	27
	Autumn lambing: 12.4 ewes/ha Replicate 3	59	9
1962	Autumn lambing: 12.4 ewes/ha Replicate 2	36	10
	Spring lambing: 12.4 ewes/ha Replicate 3	49	12

Sheep were fed a ration of 50:50 oat grain:commercial sheep pellets when the mean liveweight fell below 37 kg. In addition, at each joining period a supplementary ration of about 200 g of oat grain/ewe.d was fed, partly to allow for extra consumption of pasture by the ram.

Observations

The rams were equipped with "Sire-sine" marking crayons (Radford, Watson and Wood 1960) and oestrus records were obtained daily throughout the joining period of 42 d. Plots were inspected once daily throughout lambing to record ewe lambing performances, lamb identity, lamb birth weight, and to conduct autopsies on dead lambs.

Ewe liveweights were measured every four weeks except during late pregnancy and early lactation when they were weighed every two weeks.

Results

Liveweight change in the ewes

The patterns of liveweight change (42 ewes in each treatment) for the four years are shown in figure 1. The graphs show that for most of the year there was an effect of stocking rate on liveweight. The ewes stocked at 3.7/ha were heaviest, those at 12.4 were lightest and those at 7.4 were intermediate. There were instances when sheep at the two highest stocking rates were heavier than those at the lowest stocking rate, such as in the autumn group in 1961, but these were exceptional.

The effects of time of lambing and stocking rate on liveweight patterns for pregnant ewes in relation to stage of gestation are shown in figure 2. The weight when the ewes were 150 d pregnant was less accurate than their weight at earlier stages, because it was estimated by extrapolating from the last two weights before lambing.

Irrespective of stocking rate, it appeared that autumn lambing ewes suffered a net loss of liveweight during the last 50 d of pregnancy when allowance is made for the weight of the conceptus. The maximum gain over the last 50 d of pregnancy was 4.5 kg (which resulted in a net loss) by the 3.7 ewes/ha group in 1960. In 1962 there was a loss in gross liveweight at all stocking rates.

With winter lambing, at all stocking rates in all years (except at the high stocking rate in 1962) ewes gained .-eight in late pregnancy. There was a net liveweight gain by all spring lambing ewes at all stocking rates in all years.

Although liveweight gain during late pregnancy was clearly in favour of lambing at a later time of the year, this is not true of liveweight at mating. The effect of treatments on liveweight at the start and end of joining is shown in table 3. The ewes joined in late spring (autumn lambing) were the heaviest sheep at joining and the autumn joined groups the lightest (P < 0.01). The 1959 data are not reported here because the treatments had not been imposed before joining. There

were liveweight differences (P < 0.05) because of stocking rate at joining for the ewes lambing in autumn 1961.

Table 3

Liveweights of ewes at joining (Mean of 1960, 1961 and 1962)

Lambing time	Stocking rate (ewes/ha)	Liveweight at start of joining (kg)	Liveweight at end of joining (kg)
Autumn	3.7	49.7	49.3
	7.4	50.8	50.3
	12.4	48.9	47.9
Winter	3.7	48.6 } *	46.4 } *
	7.4	47.7 }*	46.2 }*
	12.4	45.2	43.7
Spring	3.7	44.8 }* } *	44.2 }* } *
	7.4	41.5 }*	41.0
	12.4	39.6	39.1

*P < 0.05

Oestrus

There were only two occasions when some ewes failed to exhibit oestrus throughout the joining periods in spring, 1960, at 12.4 ewes/ha and in autumn, 1962, also at 12.4 ewes/ha. In each case, failure to exhibit oestrus was restricted to ewes on one replicate only and appeared to be associated with low liveweights. The mean liveweight of the 4 ewes failing to come into oestrus in November/December 1960, was 41.7 kg compared with a mean of 45.0 kg for all ewes on the plot. The mean liveweight of the 3 ewes not exhibiting oestrus in March/April 1962 was 28.0 kg, compared with a mean liveweight of 32.3 kg for all ewes on the plot. The number of ewes involved was too small for statistical significance.

It appears that with a March/April joining, undernutrition has to be severe before the exhibition of oestrus is suppressed in Merino ewes. With a November/December joining, a less severe undernutrition may suppress oestrus.

There was a marked effect of stocking rate (P < 0.01) on the pattern of oestrus with the mid-November to December 1959 joining. Sixty and 67% of the ewes at the low and intermediate stocking rates respectively exhibited oestrus in the first 14 d compared with only 19% at the high stocking rate (P < 0.01). There was no clear effect of stocking rate upon oestrus in other years or at other times of lambing. Figure 1 shows that there were liveweight differences (P < 0.05) due to stocking rate at joining for the ewes lambing in autumn 1961.

Table 4 shows the proportion of ewes exhibiting oestrus for each time of joining.

Table 4

Percentage of ewes marked during joining (Mean of 1960, 1961, 1962)

Time of joining	Interval of joining period		
	First 14 d	Second 14 d	Third 14 d
November-December	30.7	47.5	21.8
January-February	45.2	32.0	22.8
March-April	59.4	26.6	14.0

The lamb drop in the autumn group which was not teased during joining was concentrated into the second two week period irrespective of stocking rate. In the winter group, a higher proportion of ewes lambed in the first two weeks while lambing was virtually completed within the first three weeks in the spring group.

Fertility

Table 5 shows that, regardless of stocking rate or time of lambing, there was a high proportion of barren ewes (14-52%). This is also seen in table 6 which gives the χ^2 values for the cumulative effect of year, stocking rate and time of lambing on the proportion of barren ewes.

Table 5

Reproductive performance of ewes in relation to time of lambing and stocking rate. (No. of ewes joined in each cell = 42)

Lambing time	Stocking rate (ewes/ha)	Ewes lambing (%)	Ewes twinning (%)	Lambs marked (%)	Lambs weaned (%)	Lambs reared /ha
(a) 1959						
Autumn	3.7	69	7	64	62	2.3
	7.4	81	6	86	69	5.1
	12.4	76	9	71	71	8.8
Winter	3.7	55	6	45	45	1.7
	7.4	50	2	45	40	3.0
	12.4	52	6	45	36	4.4
Spring	3.7	60	2	48	45	1.7
	7.4	71	0	52	52	3.9
	12.4	76	9	64	64	8.0
(b) 1960						
Autumn	3.7	83	12	83	76	2.8
	7.4	86	6	81	81	6.0
	12.4	69	2	55	52	6.5
Winter	3.7	71	6	64	62	2.3
	7.4	69	12	55	55	4.1
	12.4	55	14	45	43	5.6
Spring	3.7	74	17	88	88	3.3
	7.4	76	10	74	71	5.3
	12.4	52	7	55	52	6.8
(c) 1961						
Autumn	3.7	71	0	52	52	1.9
	7.4	69	2	62	62	4.6
	12.4	71	10	60	60	7.4
Winter	3.7	74	10	67	67	2.8
	7.4	64	12	40	36	2.6
	12.4	67	6	45	43	5.0

Table 5 (continued)

Reproductive performance of ewes in relation to time of lambing and stocking rate.
(No. of ewes joined in each cell = 42)

Lambing time	Stocking rate (ewes/ha)	Ewes lambing (%)	Ewes twinning (%)	Lambs marked (%)	Lambs weaned (%)	Lambs reared per ha
	3.7	81	2	69	64	2.4
Spring	7.4	86	10	83	83	6.2
	12.4	81	0	62	62	7.7
			(d) 1962			
	3.7	69	0	55	55	2.1
Autumn	7.4	62	7	38	36	2.6
	12.4	53	2	31	29	3.6
	3.7	62	6	60	60	2.2
Winter	7.4	69	14	57	57	4.2
	12.4	55	2	36	33	4.1
	3.7	69	2	69	69	2.7
Spring	7.4	62	2	55	52	3.9
	12.4	48	6	45	43	5.3
			(e) Overall data for 1959-1962			
	3.7	73	5	64	61	2.2
Autumn	7.4	74	5	63	62	4.6
	12.4	67	5	54	53	6.6
Mean		72	5	60	59	4.6
	3.7	66	6	59	58	2.1
Winter	7.4	63	8	49	47	3.7
	12.4	57	7	43	39	4.9
Mean		62	7	51	48	3.6
	3.7	71	6	68	67	2.5
Spring	7.4	74	5	66	65	4.9
	12.4	64	5	57	55	6.9
Mean		70	5	64	62	4.7
Overall means for stocking rate	3.7	70	6	64	62	2.3
	7.4	70	6	60	58	4.3
	12.4	63	6	51	52	6.1

The proportion of barren ewes was significantly higher ($P < 0.01$) with winter than either autumn or spring lambing. By 1962, the proportion of barren ewes ($P < 0.001$) (table 5) had risen in the autumn and spring groups to the same level as the winter group, with the higher proportion of barren ewes being amongst those grazed at 12.4 ewes/ha. The high proportion of barren ewes (32.2%) throughout the experiment was the most important source of reproductive wastage in this flock. Nevertheless, the overall lambing percentage was very similar to the average for the district through the 1960s.

The proportion of barren ewes was not affected by increasing the stocking rate from 3.7 to 7.4 ewes/ha. However, increasing the stocking rate from 7.4 to 12.4 ewes/ha did increase the proportion of barren ewes ($P < 0.001$). The increased proportion of barren ewes associated with increasing the stocking rate from 7.4 to 12.4, although serious, was nevertheless small compared with the generally high incidence of barren ewes (29%) at the two lowest rates.

The liveweight loss of autumn lambing ewes receiving no supplementary feed in this experiment appears to conflict with the findings of Thomson and Aitken (1959). They found that lamb losses were higher in ewes which failed to gain at least 5 kg in late pregnancy. Although the weight of the lambs at birth was lower in autumn there was no difference between autumn and spring lambing in the level of lamb mortality. This

Table 6

χ^2 values for the effect of year, stocking rate and lambing time on proportion of barren ewes

Source	Degrees of freedom	χ^2	Significance
Years	3	11.13	*
Lambing times	2	13.11	**
Stocking rates	2	16.86	***
Stocking rates, 1959	2	0.92	ns
Stocking rates, 1960	2	16.16	***
Stocking rates, 1961	2	1.24	ns
Stocking rates, 1962	2	17.31	***
Lambing times, 1959	2	16.46	***
Lambing times, 1960	2	17.27	***
Lambing times, 1961	2	11.98	**
Lambing times, 1962	2		*
Lambing times x years	6	38.10	***
Stocking rates x years	6	18.56	**
Stocking rates x lambing times	4	3.10	ns
Stocking rates x lambing Times x years	12	15.90	ns

* $P < 0.05$ ** $P < 0.01$ *** $P < 0.001$

was probably associated with autumn being dry and relatively warm so that bad weather did not induce greater losses amongst the lighter lambs.

The low proportion of ewes twinning in this experiment meant a negligible (two cases) incidence of pregnancy toxaemia. The undernutrition encountered was not severe enough to precipitate clinical pregnancy toxaemia.

There were no significant differences in liveweight between barren and monotocous ewes at joining. The mean liveweight at mating of polytocous ewes was significantly higher than monotocous ewes ($P < 0.001$ in 1959-60 and 1960-61, and $P < 0.01$ in 1961-62). This result differs from general experience on the effect of liveweight on fertility in sheep (Coop and Hayman 1962) when monotocous ewes are usually heavier than barren ewes.

From the data reported here, undernutrition with a March/April joining has to be severe before overt oestrus is suppressed in Merino ewes. With a November/December joining a less severe undernutrition may suppress oestrus. Watson and Radford (1966) found a relationship between physical condition and occurrence of mating in winter. They suggested that the sexual season in ewes in "fair" and "poor" condition (a condition score of 2 on a scale of 0 to 5 where 0 is emaciated and 5 is over-fat) was shorter than that of ewes in good condition. Failure to exhibit oestrus is unlikely to be an important factor affecting reproductive failure in Merino ewes mated on pasture in the agricultural areas of Western Australia.

The length of the oestrous cycle of ewes returning to service was 17 d. This suggests that either failure of fertilization or embryonic mortality within the first 12 d *post coitum* was the reason for the infertility. Whether this was due to failure of sperm transport, failure to fertilize the ovum or embryonic mortality was not determined.

These results indicate that ewes failing to conceive was a major source of wastage. Serious as the infertility is (29% of ewes joined failed to conceive) from an economic viewpoint, it is important to note that the barrenness was not increased when the stocking rate was raised from 3.7 to 7.4 ewes/ha.

The greater incidence of barren ewes in the winter is difficult to explain. The high temperatures of January and February may have affected fertility in the rams and/or the ewes. The semen characteristics of the rams used appeared to be little different from that at the other two times of joining.

The reason for a higher degree of barrenness in 1962 is unknown. Since there was no culling for barrenness after 1959, the higher proportion of barren ewes in 1962 (39% compared with 29% in 1959, 1960 and 26% in 1961), particularly at the higher stocking

rate, can possibly be ascribed to more ewes being affected by the continuous ingestion of phyto-oestrogens.

At the end of the experiment, uteri from 129 ewes from all treatment groups were examined (Davies and Nairn 1964). The high proportion of ewes with cystic hyperplasia of the endometrium was strongly indicative that some of the infertility was due to ingestion of phyto-oestrogens. The proportion of subterranean clover in the pastures fluctuated between seasons and treatments (Davies 1965), but at no time was it more than 40% of the pasture on offer. The mean over all seasons and treatments was 24%. Thus, sheep fertility can probably be reduced on pastures where subterranean clover is not the dominant component.

There was no significant effect of time of lambing upon prolificacy. This result is at variance with the findings of Allden (1965) and Reeve and Sharkey (1980) for British breeds, and Morley (1948), Watson (1953), Radford (1959) and Dun *et al.* (1960) for the Merino. Two explanations can be proffered for these differences:

- The strain of sheep used in this experiment came from a line which had lambed in the autumn for several years and may not have been a prolific strain.
- The 20% weight loss between joining in November compared with joining in March may well have negated any favourable effect of autumn joining upon prolificacy.

Although changing the time of lambing from autumn to winter or spring did not result in a higher lamb marking percentage it enabled more sheep to be carried per hectare without recourse to supplementary feeding and resulted in more efficient pasture use.

Figure 1A(1). Liveweight changes of ewes – autumn lambing – 1959.

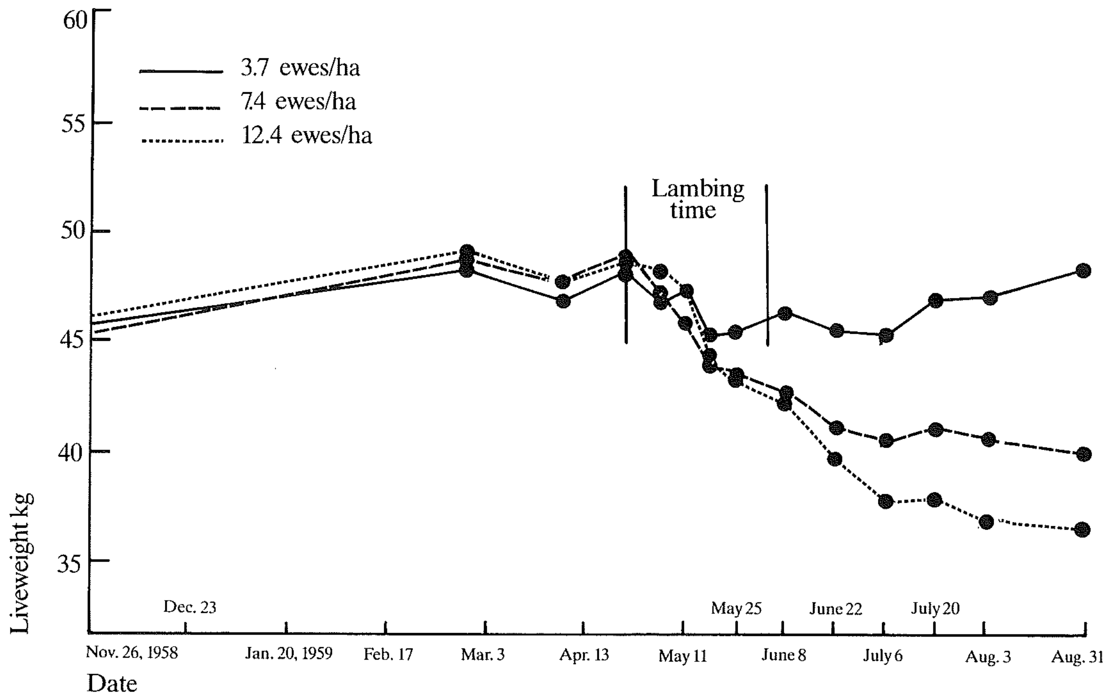


Figure 1A(2). Liveweight changes of ewes – winter lambing – 1959.

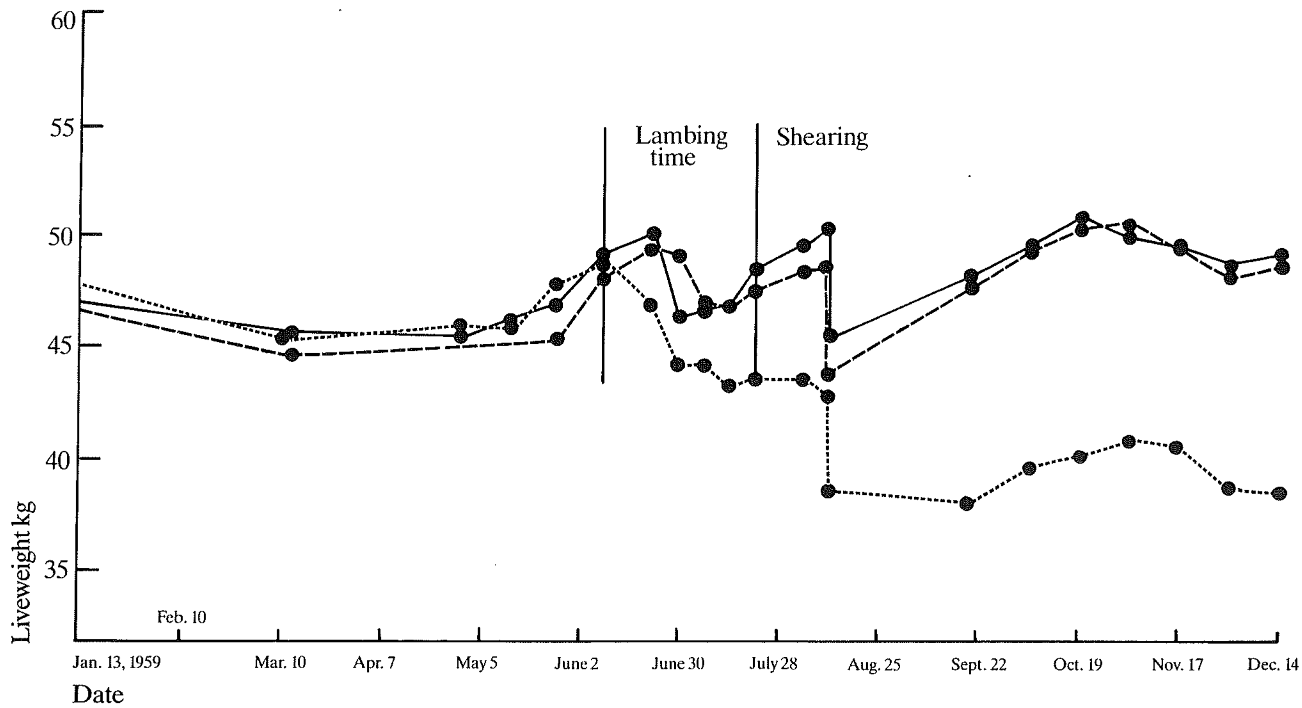


Figure 1A(3). Liveweight changes of ewes – spring lambing – 1959.

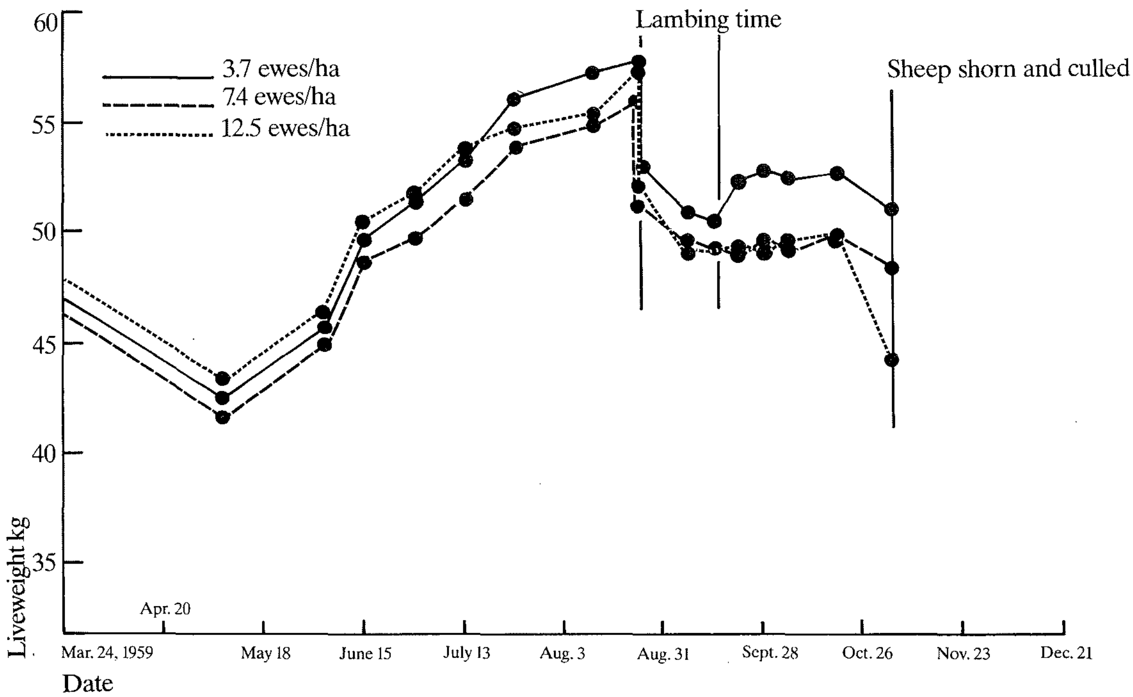


Figure 1B(1). Liveweight changes of ewes – autumn lambing – 1960.

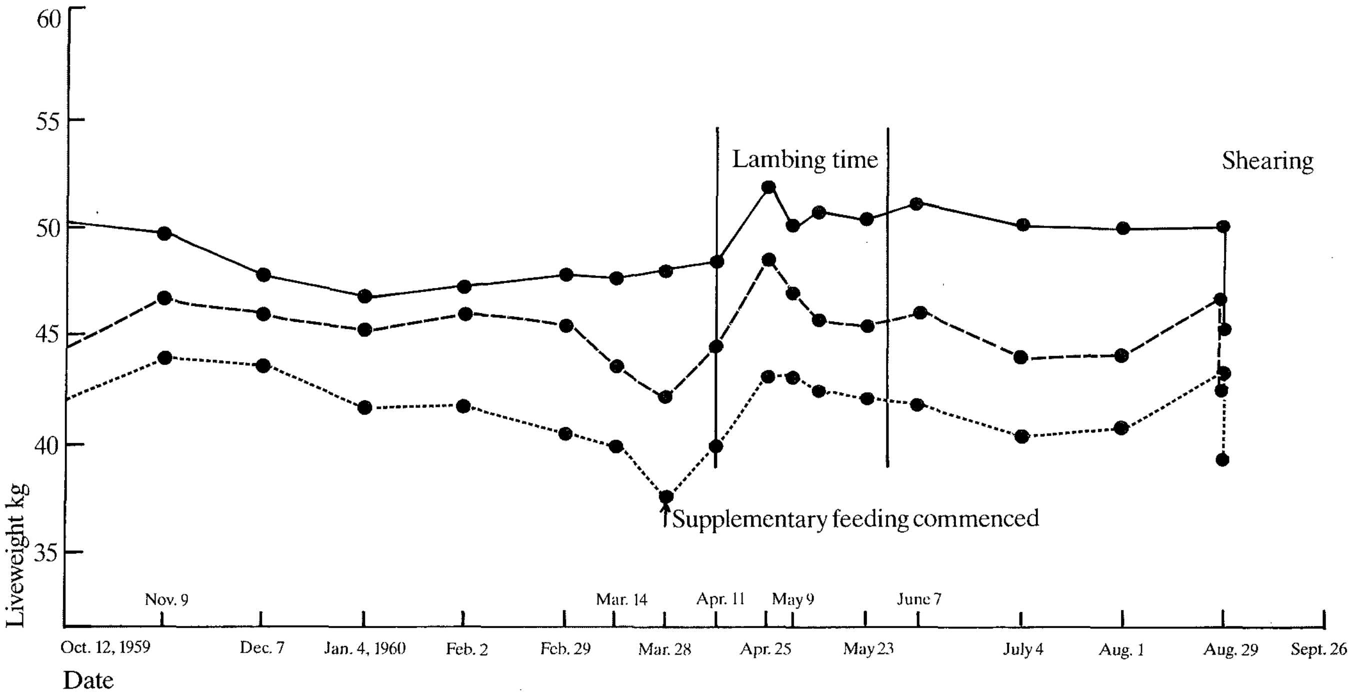


Figure 1B(2). Liveweight changes of ewes – winter lambing – 1960.

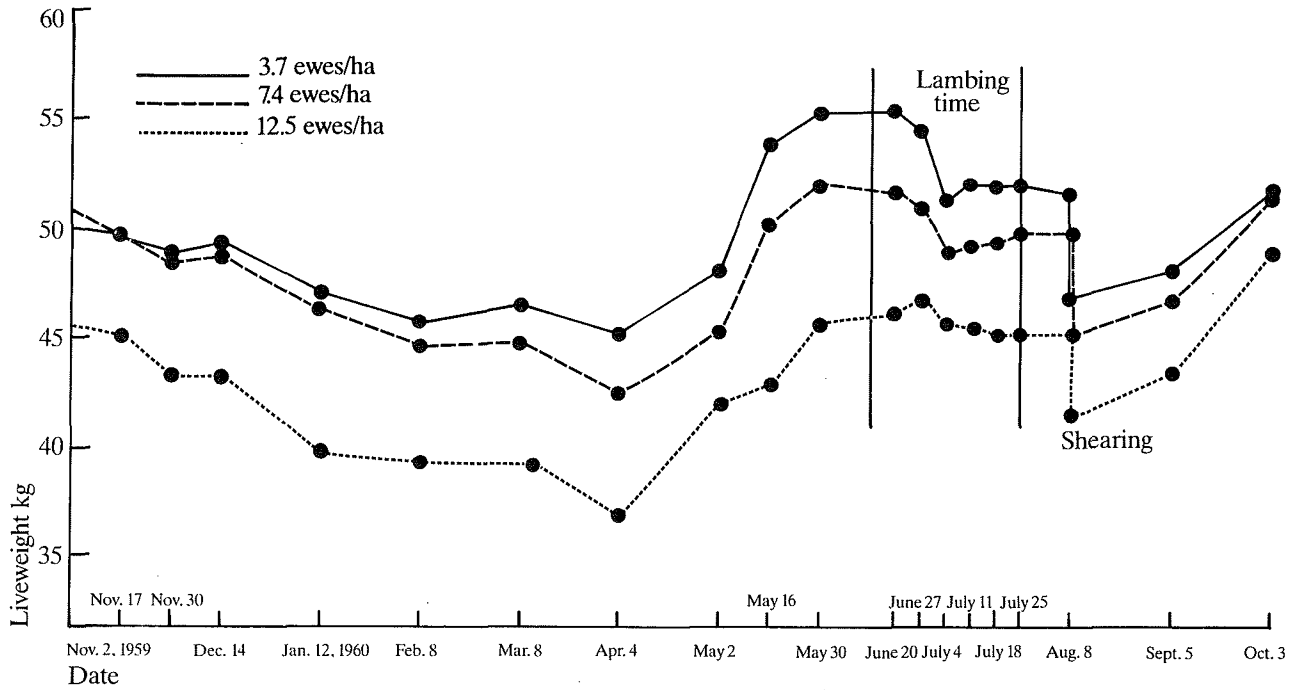


Figure 1B(3). Liveweight changes of ewes – spring lambing – 1960.

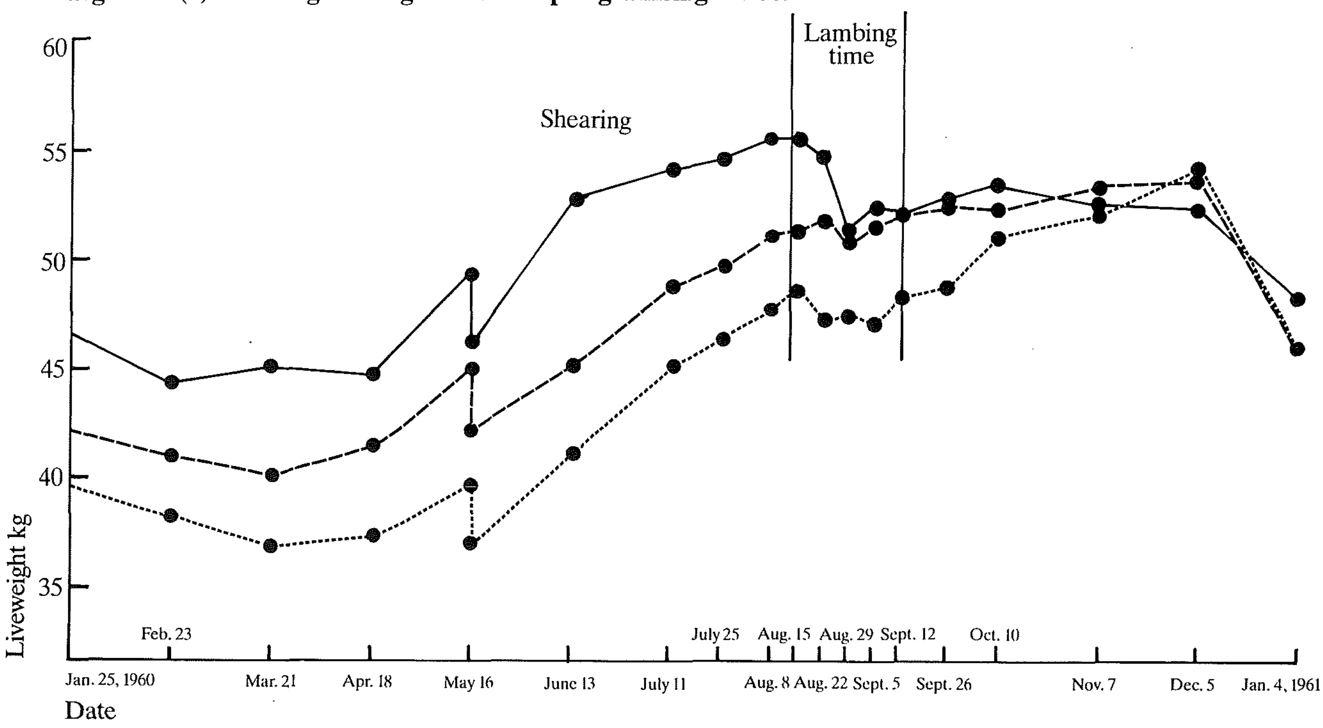


Figure 1C(1). Liveweight changes of ewes – autumn lambing – 1961.

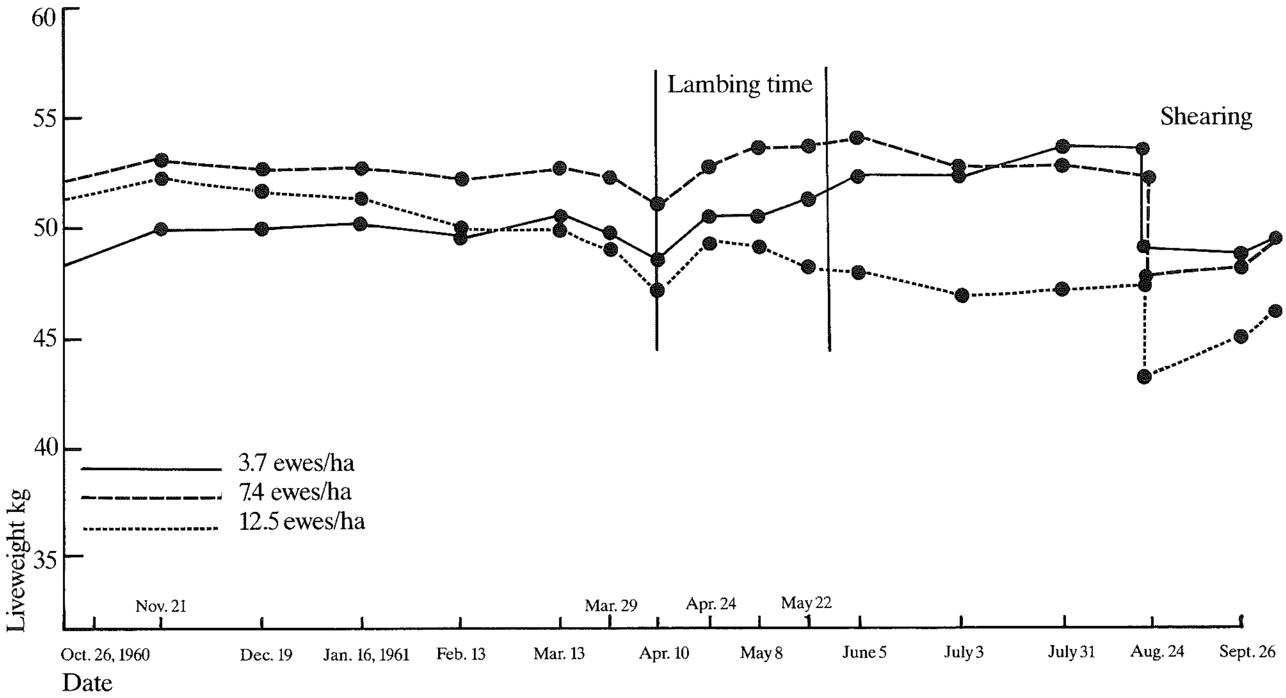


Figure 1C(2). Liveweight changes of ewes – winter lambing – 1961.

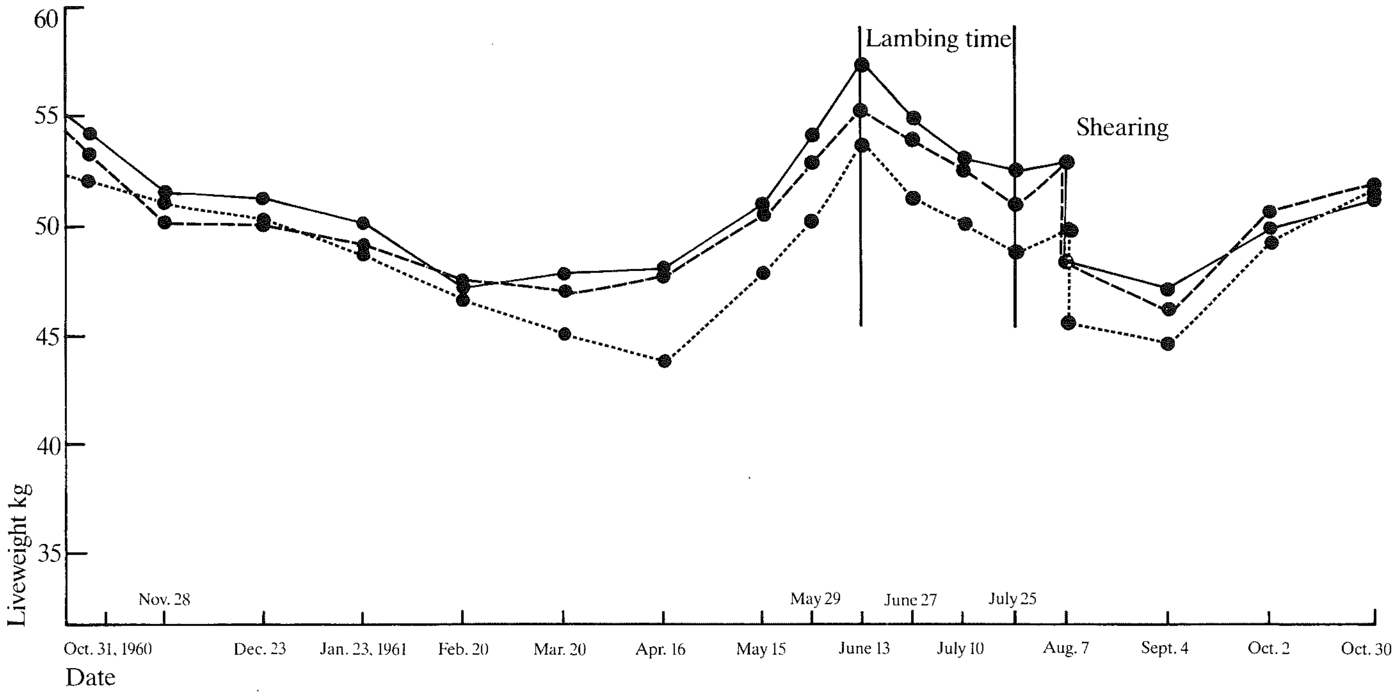


Figure 1C(3). Liveweight changes of ewes – spring lambing – 1961.

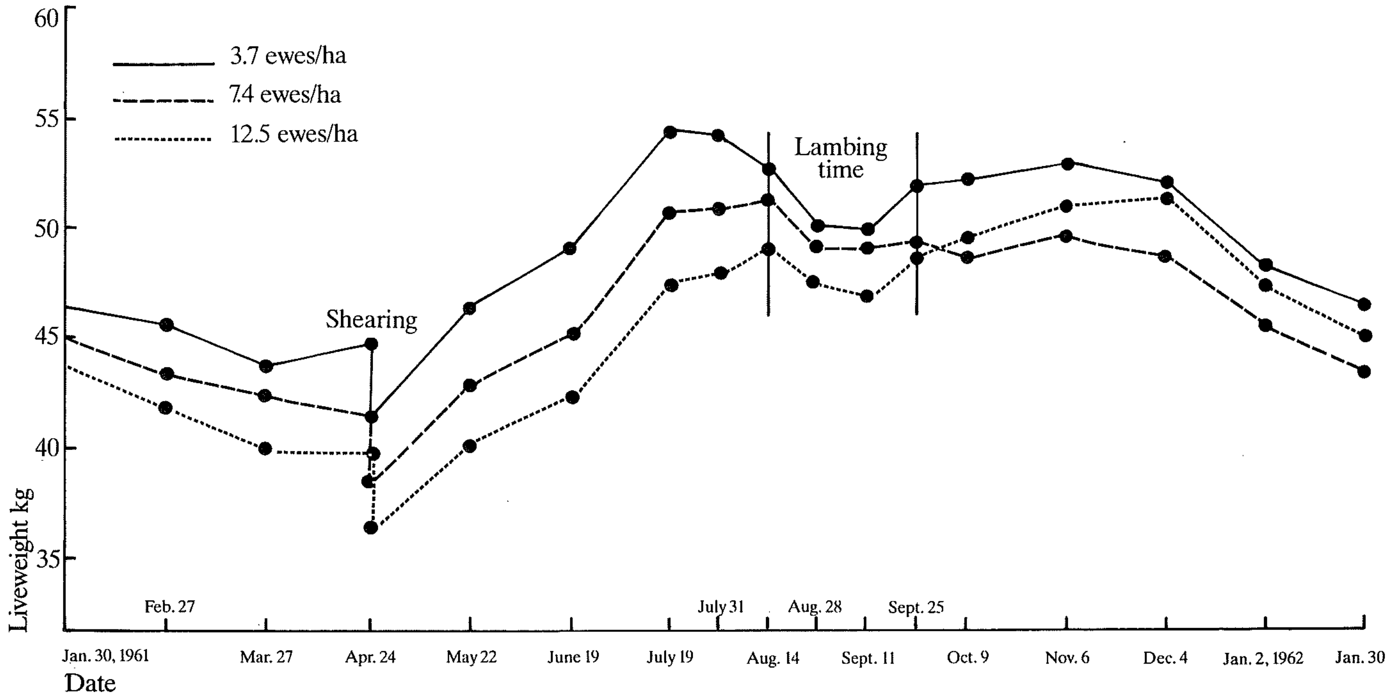


Figure 1D(1). Liveweight changes of ewes – autumn lambing – 1962.

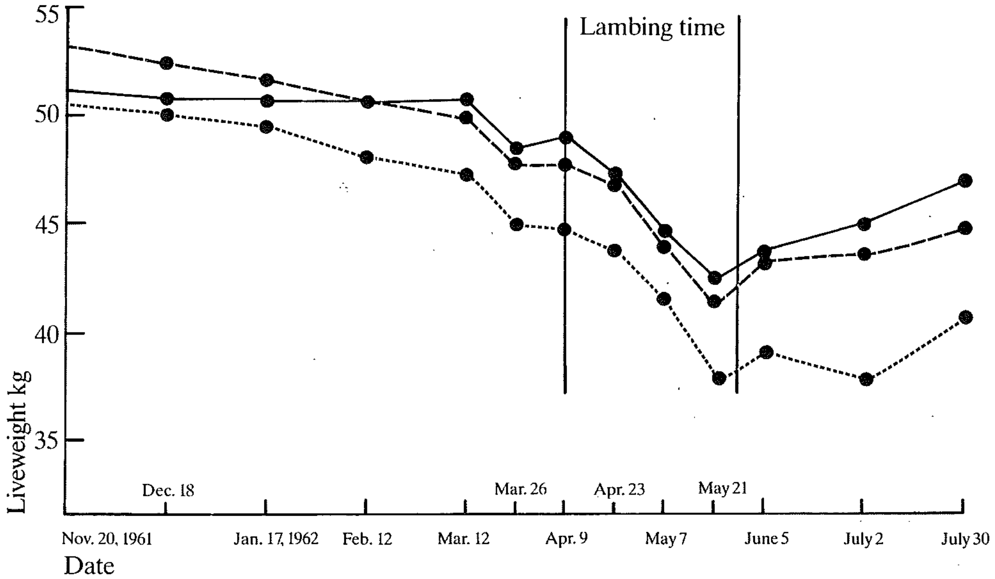


Figure 1D(2). Liveweight changes of ewes – winter lambing – 1962.

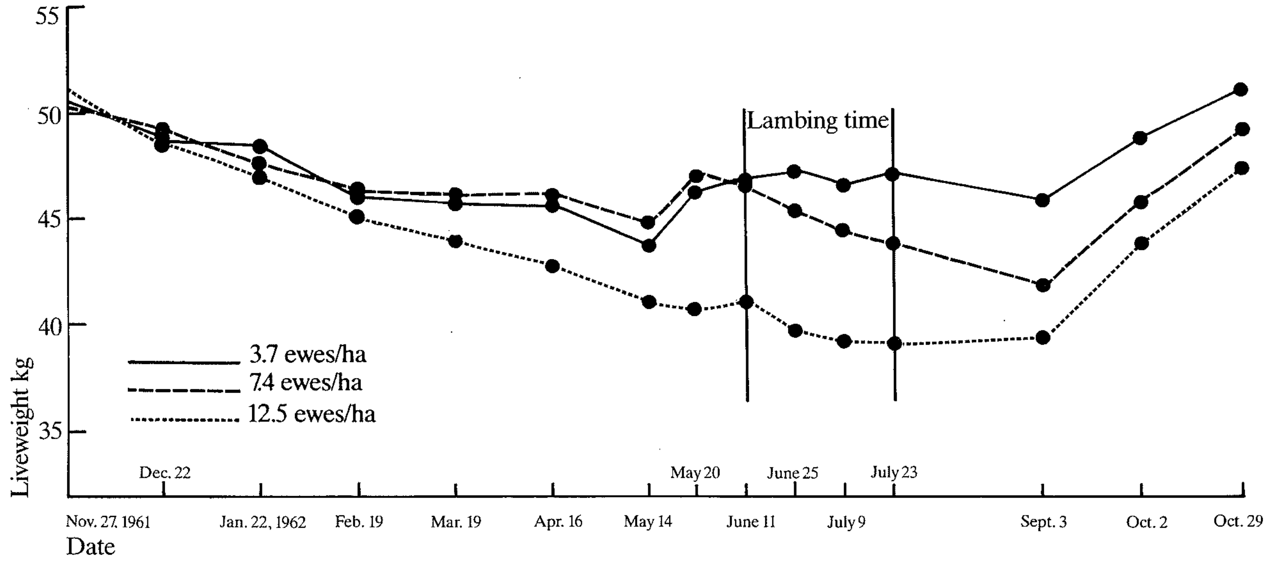


Figure 1D(3). Liveweight changes of ewes – spring lambing – 1962.

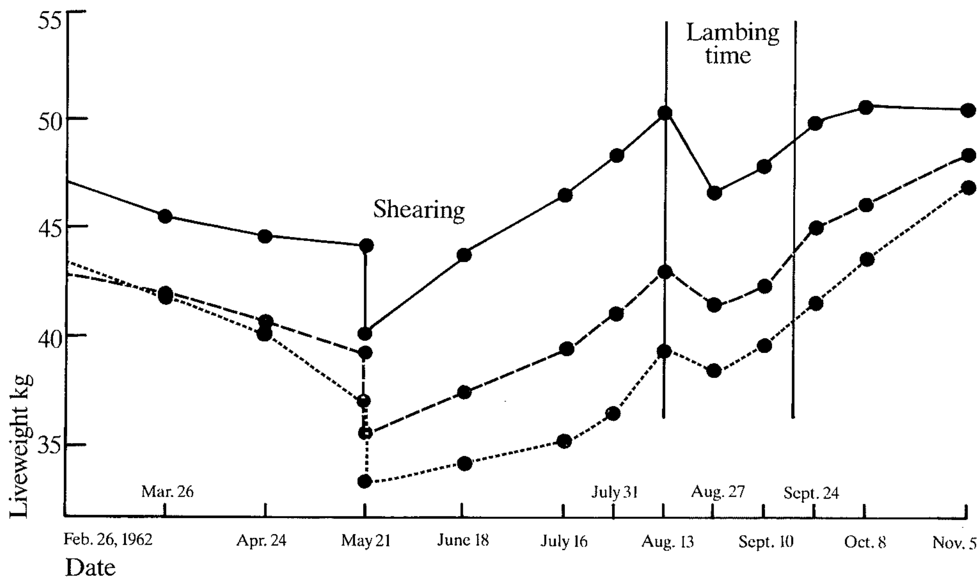


Figure 2A(1). Liveweight change of ewes in relation to number of days pregnant – autumn lambing – 1960

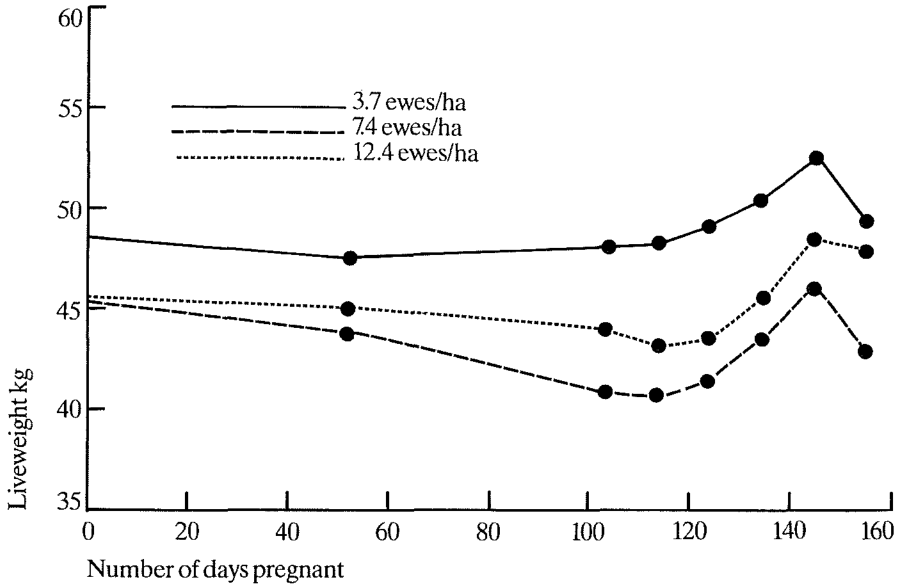


Figure 2A(2). Liveweight change of ewes in relation to number of days pregnant – autumn lambing – 1961.

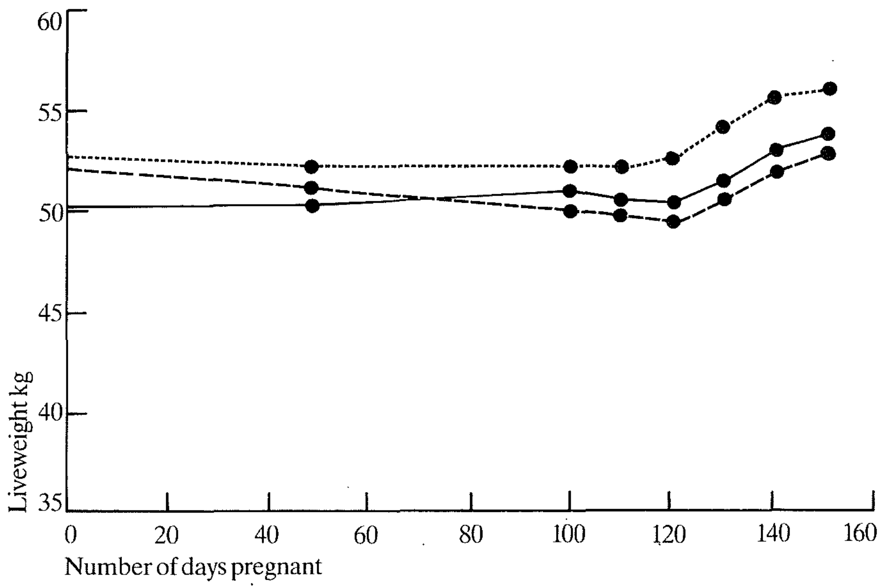


Figure 2A(3). Liveweight change of ewes in relation to number of days pregnant – autumn lambing – 1962.

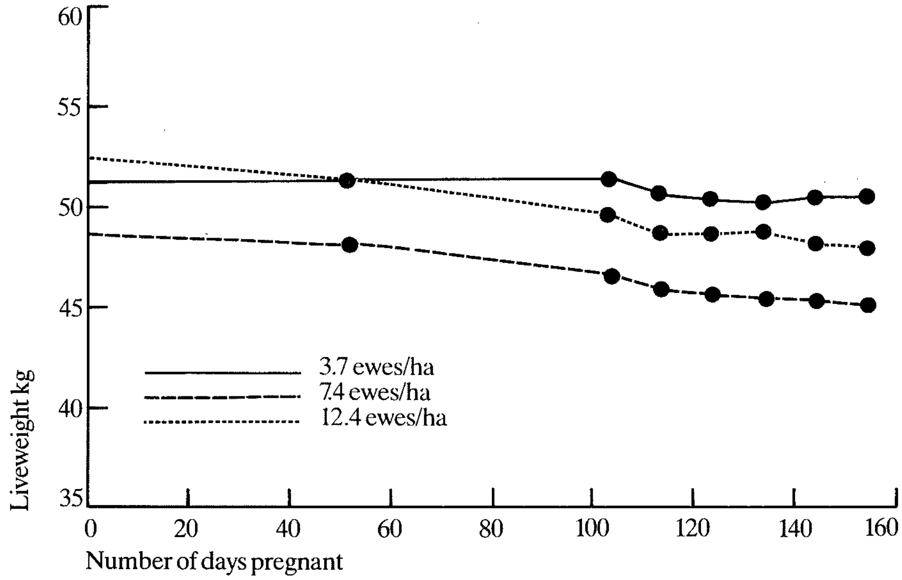


Figure 2B(1). Liveweight change of ewes in relation to number of days pregnant – winter lambing – 1960

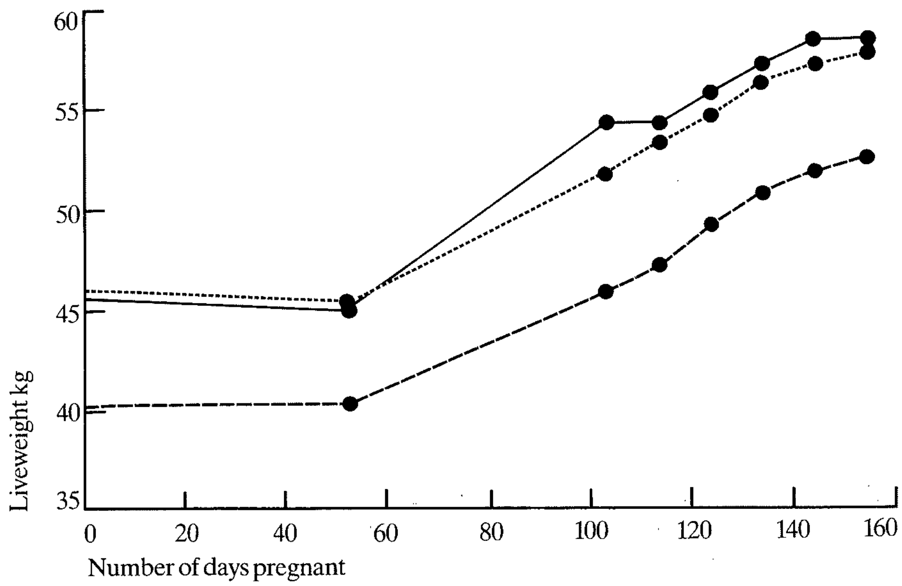


Figure 2B(2). Liveweight change of ewes in relation to number of days pregnant – winter lambing – 1961.

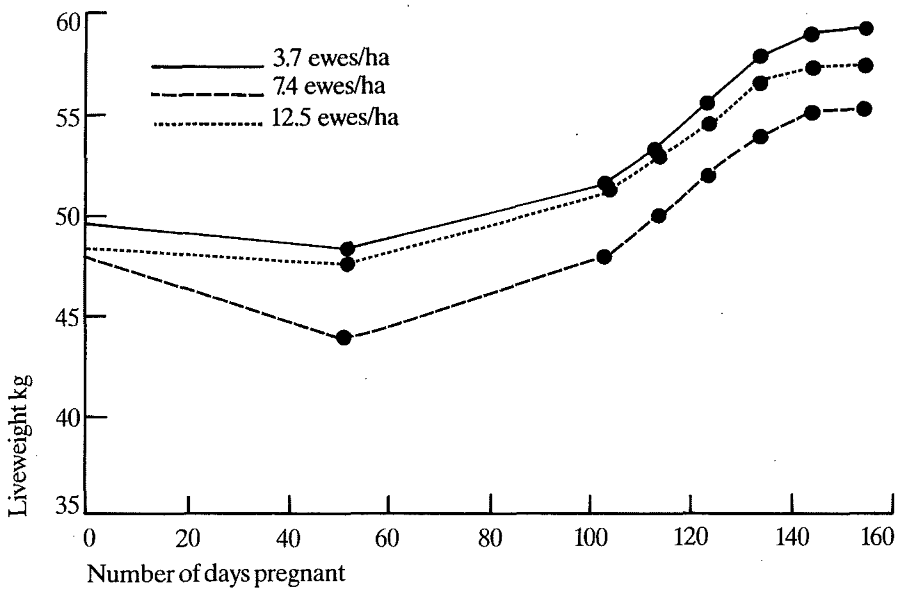


Figure 2B(3). Liveweight change of ewes in relation to number of days pregnant – winter lambing – 1962.

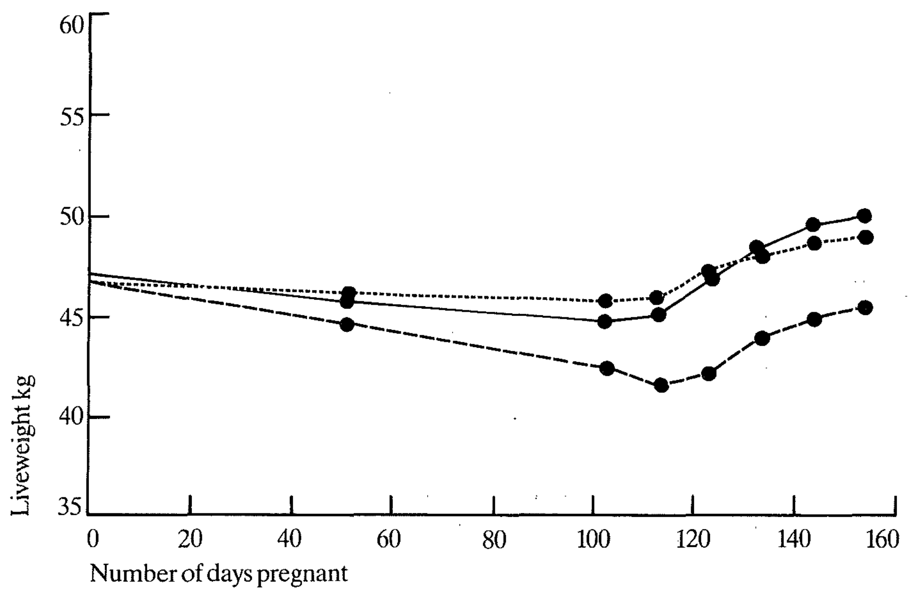


Figure 2C(1). Liveweight change of ewes in relation to number of days pregnant – spring lambing – 1960

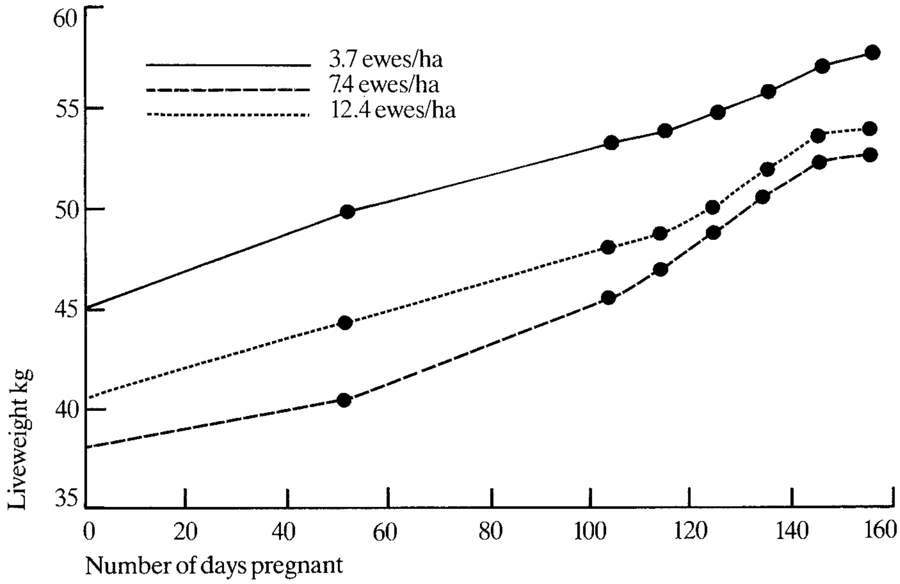


Figure 2C(2). Liveweight change of ewes in relation to number of days pregnant – spring lambing – 1961.

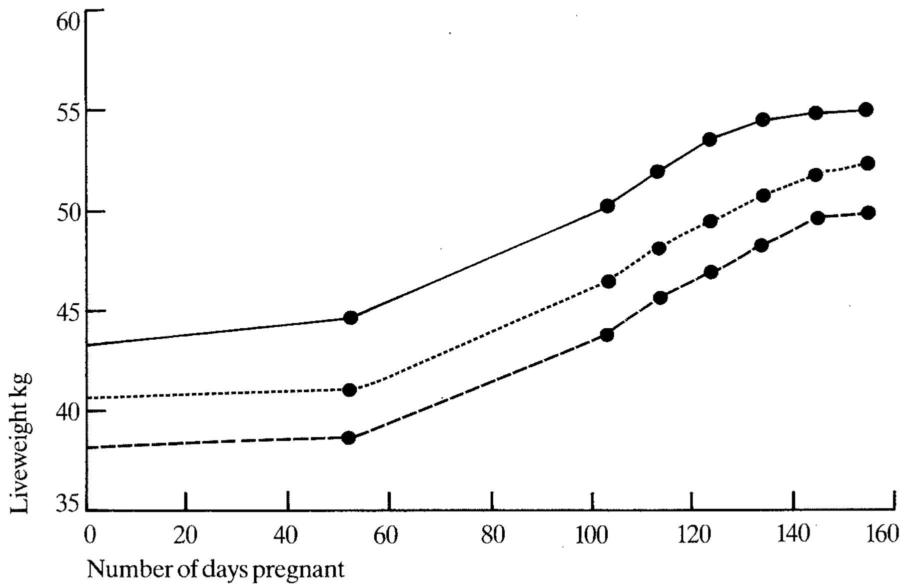
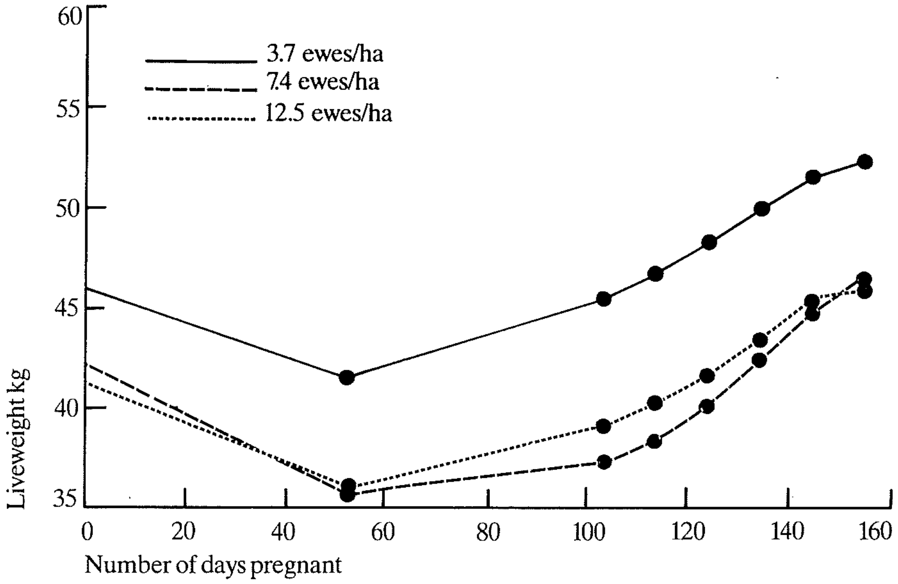


Figure 2C(3). Liveweight change of ewes in relation to number of days pregnant – spring lambing – 1962.



Part 2—Lamb losses

Summary

High levels of lamb mortality were a major source of wastage contributing to the generally (see Part 1) low lamb marking percentages reported in this study. Most lamb deaths occurred within 72 h of birth.

There was little difference in lamb loss between autumn (19.0%) and spring (17.0%) lambings. However, losses were significantly ($P < 0.01$) higher in winter (26.7%). Lamb losses in winter sometimes appeared to be associated with a higher level of predator activity.

There was a 39% loss among twin lambs compared with a 21% loss among single lambs. Among single lambs, losses increased with increasing stocking rate, *viz.* 3.7 ewes/ha—19.9%; 7.4 ewes/ha—28.7% and 12.4 ewes/ha—33.6%.

Introduction

Throughout Australia, perinatal lamb mortality is a major source of reproductive wastage in sheep flocks. Lamb mortality varies from 10 to 30% (Alexander, McCance and Watson 1955) with approximately 80% of these dying within the first 3 d of life. Most observers have found that the major causes are nutritional, behavioural and/or physiological and that infections play a relatively unimportant role (Alexander *et al.*, 1955; Alexander, Peterson and Watson, 1959; Dennis, 1974).

Materials and methods

The plots detailed in Part 1 were examined daily throughout lambing and the weights of newly born lambs recorded to the nearest 30 g. The presumptive dam was caught and her udder examined. Dead lambs were autopsied and classified as an ante-parturient death if the lungs were not expanded. Birth coats were classified by the method of Schinckel (1955) into fine, intermediate and hairy.

Statistical analysis

Analysis of variance was carried out on the arc-sine transformation of per cent lambs dead (to lambs born).

Results and discussion

Mortality and time of lambing

Table 7 shows the effect of times of lambing on losses among single lambs.

Both the total number of lambs lost and proportion of lambs lost to lambs born were higher during winter (P < 0.01) than for either autumn or spring.

The losses for single lambs born during winter are recorded in table 8. There were particularly high losses at both the intermediate and high stocking rates. Relatively few multiple births were recorded and there were no significant differences between seasons in losses among twins (autumn 47%, winter 38% and spring 50%).

Compared with autumn, lamb losses during mid-June to July were always high in spite of the availability of green pasture. This may have been associated with higher losses due to exposure and predator activity. The deaths associated with predators occurred during the neo-natal period and may not have been primarily due to predator attack.

Mortality and stocking rate

Losses amongst single lambs increased with increasing stocking rate (table 9). In spite of the more severe losses at the highest stocking rate the number of lambs reared/ha was higher. The incidence of twin lambs was too low to allow for any conclusions concerning the effects of stocking rate upon these lamb deaths.

Table 7

Effect of time of lambing on deaths of single lambs

Nature of death	Lambing time	Lambs born (no.)	Lambs dead (no.)	Lamb mortality (%)			% of deaths at each time
Stillbirth	Autumn	337	13	3.9	n.s.		20.3
	Winter	273	14	5.1		n.s.	19.2
	Spring	330	14	5.8	n.s.		24.6
Deaths from birth to 3 d with no sign of predator attack	Autumn	337	27	8.0	n.s.		42.2
	Winter	273	27	9.9		*	37.0
	Spring	330	21	6.4	**		36.8
Deaths associated with predation	Autumn	337	14	4.1	*		21.9
	Winter	273	26	9.5		n.s.	35.6
	Spring	330	12	3.6	*		21.1
Deaths from 3 d to weaning	Autumn	337	10	3.0	n.s.		15.6
	Winter	273	6	2.2			8.2
	Spring	330	10	3.0	n.s.		17.5
Total single lamb losses	Autumn	337	64	19.0	*		
	Winter	273	73	26.7		n.s.	
	Spring	330	57	17.4	**		

n.s. = not statistically significant. * = P < 0.05 ** = P < 0.01

Table 8

Single lamb losses during winter lambing for all years

Stocking rate (ewes/ha)	Lambs born (no.)	Lambs dead (no.)			Lamb mortality (%)		
3.7	100	13	**		13	**	**
7.4	80	32		**	40		
12.4	84	30			36	n.s.	

**P < 0.01

Table 9

Effect of stocking rate on total lamb losses

Nature of death	Stocking rate (ewes/ha.)	Lambs born (no.)	Lambs dead (no.)	Lambs mortality (%)	Total lamb loss (%)
Stillbirth	3.7	386	15	3.4	17.3
	7.4	396	21	5.3	18.6
	12.4	351	12	3.4	10.2
Deaths from birth to 3 d with no sign of predator attack	3.7	386	30	7.8 ** **	40.0
	7.4	396	54	13.6	47.8
	12.4	351	49	14.0	41.5
Deaths associated with predation	3.7	386	19	4.9	25.3
	7.4	396	27	6.8	23.9
	12.4	351	33	9.4	28.0
Deaths from 3 d to weaning	3.7	386	13	3.4	17.3
	7.4	396	11	2.8	9.7
	12.4	351	24	6.8	20.3
Total losses (inclusive of multiple births)	3.7	386	77	19.9 ** **	
	7.4	196	113	28.5	
	12.4	351	118	33.6	

** $P < 0.01$

There was an interaction between stocking rate and lambing time because it was only at 7.4 and 12.4 ewes/ha that the losses in winter were significantly higher than in autumn or spring.

Although increasing stocking rate led to higher numbers of lambs reared per hectare, there was nevertheless a reduction in the percentage of lambs reared with each increase in stocking rate. This reduction cannot simply be ascribed to differences in the level of nutrition at lambing, because the groups at the low and intermediate stocking rates were comparable in liveweight gain in late pregnancy. A possible reason for the difference was the "sheltering" effect available from the residual dry pasture from the previous season which was only evident on the plots stocked at 3.7 ewes/ha.

Birthweight and litter size.

Mortality and birthweight were inversely related (figure 3). The birthweights of lambs born in winter and spring were similar, but were significantly higher ($P < 0.01$) than those of lambs born in autumn.

Losses were higher ($P < 0.001$) among twins (39%) than singles (21%) with birthweights of 3.4 kg and 4.0 kg respectively.

Mortality and birthcoat type

There was no obvious relationship between lamb losses and birthcoat type. Losses among lambs with fine, intermediate and hairy birthcoats were 16.2, 18.9 and 17.6% respectively. These findings do not support the suggestion of Alexander (1962), based on laboratory studies, that lambs with a hairy birthcoat would have a survival advantage. He showed that wet lambs with a coarse birthcoat had a reduced heat loss due to evaporation compared with lambs with a fine birthcoat. Possibly the temperatures at Kojonup were not low enough to exploit the advantages of a hairy birthcoat.

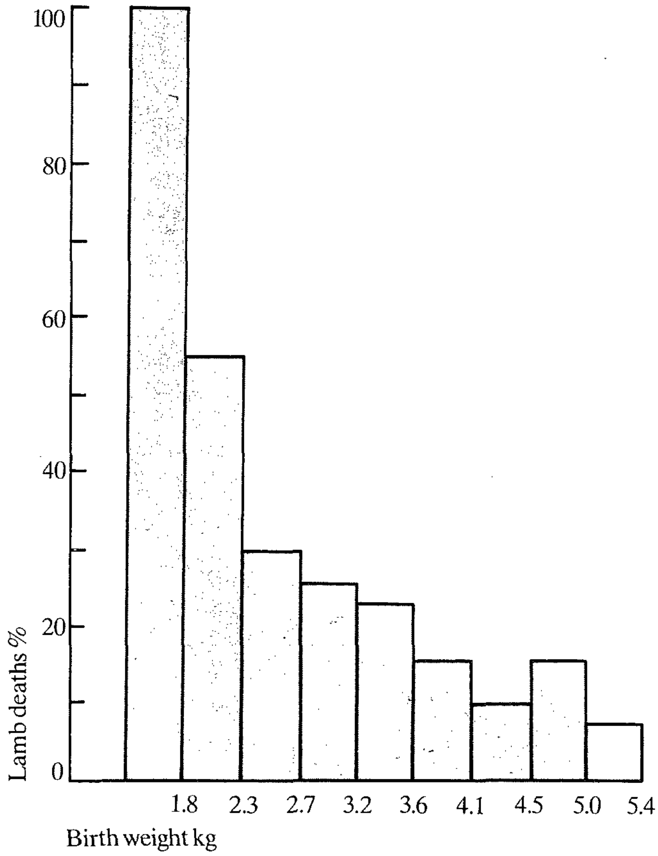
Class of death

The incidence of ante-parturient deaths was apparently independent of time of lambing (table 7), stocking rate (table 9) and year.

Predator activity was highest in winter, ($P < 0.05$, table 7) and possibly at the higher stocking rates (table 9), but it was impossible to determine how many of the deaths associated with predator activity could be attributed primarily to this cause.

Lamb losses were higher among twins than singles and also among the lighter of the single lambs in agreement with previous

Figure 3.
The relationship between lamb birthweight and mortality in lambing time × stocking rate experiment.



observations, e.g. Moule (1954); Alexander *et al.* (1955, 1959); Watson and Elder (1961).

The overall levels of lamb losses reported here are comparable with those from the Western districts of Victoria, and the Northern and Southern Tablelands of New South Wales (Alexander *et al.* 1955; Davies, 1968). There is a possibility that the daily observations may have upset the behavioural patterns of ewes and lambs and been responsible for higher neo-natal mortality than would have occurred with undisturbed grazing, but there is no critical evidence on this. However, at the same time the intensive inspections could have resulted in some ewes and lambs being saved. Therefore, the lamb losses recorded in this experiment are likely to be similar to those generally experienced in south-western Australia. The time distribution of deaths observed in this study were comparable to those Dennis (1974) obtained in his very large survey.

When oestrogenic infertility is finally removed as a reason for reproductive wastage, reduction in lamb losses could easily be one of the more important problems facing the sheep industry.

Part 3—Effect on lamb growth and subsequent growth after weaning

Summary

The effect of three times of lambing (autumn, winter and spring) and three stocking rates (3.7, 7.4 and 12.4 ewes/ha) on lamb growth and the subsequent growth of the weaners were measured.

There were some stocking rate x lambing time x year interactions. In each year, stocking rate significantly ($P < 0.05$) affected the growth of autumn-born lambs. With winter lambing, there was little difference in liveweight between the 3.7 and 7.4 ewes/ha groups, but the lambs from ewes at 12.4/ha grew at a slower rate. With spring lambing, stocking rate usually had no effect upon lamb growth. In all years, the growth rates of spring-born lambs from ewes stocked at 12.4/ha was superior to autumn-born lambs at the same stocking rate and in two years superior to the winter-born lambs at the high stocking rate over the first 12 week period.

Deaths were greatest from autumn-born weaners and weaners run at the highest stocking rate. The mean liveweight of autumn-born sheep one year after weaning was lower than that of either the winter or spring groups. This was mostly due to the lighter weight at weaning of the former 12.4 ewes/ha group. The wool production one year after weaning of autumn-born sheep was lower than that of winter or spring-born sheep.

Introduction

An important consideration in studying the interaction between times of lambing and stocking rates with breeding ewes is the growth and subsequent hogget performance of their lambs. In addition to data on lamb growth, the survival, liveweight and wool production of sheep weaned from the experiment described in Part 1 are examined here.

Materials and methods

Lamb growth to weaning

The plots were inspected every day during lambing and the lambs were weighed at birth and then weekly until the youngest was four weeks old. Lambs were then weighed fortnightly, until they were weaned.

Survival and growth post-weaning

At weaning, when the lambs were about 14 weeks old, 36 lambs were selected from each stocking rate. They were randomly allocated to two plots elsewhere on the field station and grazed at 4.9 sheep/ha in 1959 and 1960. In 1961, the sample size was increased to 54 (18 from each stocking rate). The experiment was terminated in November 1962 and, therefore, the weaners from the last year were not examined. The lambs were drenched with an anthelmintic at weaning and given a supplementary ration of about 250 g/head.d of oat grain from January to April. The autumn and winter-born weaners were shorn in March while the spring-born weaners were shorn in the following September when they were approximately 13 months of age.

Statistical analysis

Analysis of variance was carried out on the mean weights of male and female lambs for each plot. The effect of replicate was never statistically significant and has therefore been omitted from the tables.

Results

The effects of stocking rate and time of lambing on weight at birth, 4 and 12 weeks of age are shown in table 10. Lamb growth is shown graphically in figure 4.

Table 10

Effects of year, stocking rate and time of lambing on weight at birth, 4 and 12 weeks of age

Year	Lambing time	Stocking rate (ewes/ha)	Birth (kg)	Age 4 weeks (kg)	Age 12 weeks (kg)
1959	Autumn	3.7	3.6 *	9.9	21.7 *
		7.4	3.8	9.3 *	17.5 ***
		12.4	3.6 *	7.8 *	12.2 *
	Winter	3.7	4.1	11.3	24.3
		7.4	4.3	11.6 *	25.3 *
		12.4	4.1	10.6	22.0
	Spring	3.7	3.9	10.7	18.9
		7.4	4.0	10.5	17.9
		12.4	3.8	10.6	17.9
1960	Autumn	3.7	4.0	11.2	21.1 ***
		7.4	4.2 *	10.9	19.2 ***
		12.4	3.7	9.6	16.3 ***
	Winter	3.7	4.5	11.8	23.7
		7.4	4.4	11.3	23.1
		12.4	4.3	11.2	22.5
	Spring	3.7	4.2	12.4 *	24.5 *
		7.4	3.5	10.2	19.7
		12.4	3.9	11.4	22.6 *
1961	Autumn	3.7	4.3	12.0	24.7
		7.4	4.3	11.8 *	22.6 *
		12.4	3.9	10.3	18.0 *
	Winter	3.7	4.4	11.9	23.9
		7.4	4.1	11.6	23.2
		12.4	4.3	11.5	23.3
	Spring	3.7	4.4	12.0	22.7
		7.4	4.0	12.9	21.3
		12.4	4.1	11.1	21.9
1962	Autumn	3.7	3.6	8.1 *	20.0 *
		7.4	3.2 *	6.7 *	16.7 *
		12.4	3.1	6.4	14.2 *
	Winter	3.7	4.3	11.3	25.1 *
		7.4	3.9 *	9.9 *	20.6 *
		12.4	3.5	9.3	20.4
	Spring	3.7	4.6	12.4	24.4
		7.4	4.2	11.8 *	22.9
		12.4	4.4	11.2	23.5

Table 10 (continued)

Effects of year, stocking rate and time of lambing on weight at birth, 4 and 12 weeks of age

Year	Lambing time	Stocking rate (ewes/ha)	Birth (kg)	Age 4 weeks (kg)	Age 12 weeks (kg)
Four year mean	Autumn	3.7	3.9	10.3	21.9 } * } **
		7.4	3.9	9.6	19.1
		12.4	3.6	8.5	15.2 } *
	Winter	3.7	4.3	11.6	24.2
		7.4	4.2	11.1	23.1
		12.4	4.1	10.7	22.1
	Spring	3.7	4.2	11.9	22.6
		7.4	3.9	11.3	20.4
		12.4	4.1	11.1	21.4

* P < 0.05 ** P < 0.01 *** P < 0.001

There was a significant (P < 0.01) difference in birthweight between autumn and winter or spring lambing. The mean weight of the autumn-born lambs was 3.8 kg compared with 4.1 kg for both winter and spring-born lambs.

Increases in stocking rate were associated with lower birthweights (see table 10). Statistically significant (P < 0.05) differences due to stocking rate occurred on the following occasions.

- Autumn lambing

Between 7.4 and 12.4 ewes/ha in 1959, 1960 and 1961; and between 3.7 and 7.4 ewes/ha in 1962.

- Winter lambing

Between 3.7 and 7.4 ewes/ha in 1959, 1960 and 1962; and between 3.7 and 7.4 ewes/ha in 1962.

- Spring lambing

The only statistically significant difference was between 3.7 and 7.4 ewes/ha in 1960.

Statistical analysis was restricted to single lambs because of the few twins born and their uneven distribution between treatments.

Lamb growth to four weeks

Wallace (1948) and Owen (1957) showed that the mean 28 d liveweight of lambs is largely a reflection of the milk production of the ewes. The mean 28 d liveweights obtained in this experiment are therefore regarded as an assessment of the effects of stocking rate and time of lambing upon milk production in the ewes. Table 10 shows that there were marked effects of stocking rate and time of lambing on 28 d weights, with 1959 and 1962 being particularly poor years. The growth of wether lambs was always superior to that of ewe lambs.

There was an important time of lambing x year interaction (P < 0.001) due to the effect of the two poor years (1959 and 1962) upon the growth rate of the autumn-born lambs at all stocking rates (table 10) and on the winter-born lambs at the high stocking rate (12.4 ewes/ha) in 1959.

Autumn lambing

In 1959 and 1962 the four week weight was lower at all stocking rates than the weights achieved in winter and spring. These results suggest that it is only at a very low stocking rate and in a good year that the genetic potential for milk production is achieved by ewes lambing in the autumn.

Winter lambing

In 1959 and 1962 the weight at four weeks was significantly lower at the highest stocking rate. In 1962 lamb weight was also lower at 7.4 ewes/ha.

Spring lambing

At all stocking rates in all years the weight and growth rate of spring-born lambs were good (table 10 and figure 4), suggesting that nutrition for lactation was adequate at all stocking rates with spring lambing.

Lamb growth to 12 weeks

There was a significant effect of stocking rate upon 12 week weight in the autumn-born lambs (3.7 ewes/ha—21.9 kg; 7.4 ewes/ha-19.0 kg; 12.4 ewes/ha—15.2 kg).

With winter lambing, lambs at 12.4 ewes/ha were always significantly lighter than those grazed at 3.7 ewes/ha ($P < 0.001$ for 1959, 1960 and 1962; $P < 0.05$ for 1961). In 1962 the winter-born lambs at 7.4 ewes/ha were significantly lighter ($P < 0.05$) than those at 3.7 ewes/ha at 12 weeks.

The growth of spring-born lambs from ewes stocked at 12.4 ewes/ha was superior to lambs stocked at that stocking rate born in autumn in all years and to winter lambs stocked at 7.4 and 12.4 ewes/ha in 1962.

The difference in mean liveweight at 12 weeks for lambs born before and after September 1 is shown in table 11. Lambs born after September 1 were 3.6 kg lighter than those born before September 1 ($P < 0.01$).

Table 11

The effect of date of birth on 12 week weight

Stocking rate (ewes/ha)	Date of birth: On or before Sept. 1 (kg)	After Sept. 1 (kg)
3.7	23.6	19.7
7.4	21.7	17.9
12.4	22.1	18.5
Mean of all years and all stocking rates	22.4	18.7

Lamb production per hectare

The effect of stocking rate and lambing time on the total weight of lambs weaned per hectare is shown in figure 5.

The total lamb liveweight per hectare was derived by dividing the number of hectares available by the number of lambs reared to 12 weeks of age and multiplying by the mean liveweight at 12 weeks. Differences in the percentage of lambs weaned due to breakdowns in reproduction (principally conception failure in ewes and peri-natal mortality in lambs) and differences in growth rates are incorporated in figure 5.

This also shows that spring lambing at 12.4 ewes/ha consistently produced the heaviest weight of lambs weaned per hectare. The figure also shows that on two occasions (winter lambing 1959 and autumn lambing 1960) increasing stocking rate to the maximum rate resulted in a lower weight of lambs per hectare at weaning.

Post-weaning performance

The effect of previous treatment on the incidents of deaths among the samples of weaners is given in table 12.

Table 12

Incidence of deaths in sheep weaned from the lambing time x stocking rate experiment

Treatment	Detail of treatment	No. in sample	Deaths (no.)	(%)
Year	1959	108	8	7.4^{b}
	1960	108	22	20.4^{a}
	1961	159	19	11.9^{b}
Former stocking rate (ewes/ha)	3.7	130	11	8.5^{b}
	7.4	122	13	10.7^{b}
	12.4	123	25	20.3^{a}
Lambing time	Autumn	126	22	17.5^{a}
	Winter	126	15	11.9^{ab}
	Spring	123	12	9.8^{b}
Totals		375	49	13.1

Within each treatment, means with the same superscript do not differ significantly ($P < 0.01$).

Previous stocking rate was the treatment which mainly affected ($P < 0.01$) weaner mortality. The mortality was highest amongst the weaners from the ewes stocked at 12.4/ha which lambed in autumn and winter.

Liveweight gain

The autumn and winter-born lambs continued to gain weight after weaning until the pastures matured in November. The growth of the weaners in relation to calendar dates is shown in figure 6.

This figure shows that at any particular date the older weaners; that is, the autumn born, were heavier than the winter born lambs which, in turn, were heavier than the spring born lambs at the low and intermediate stocking rates. This was not always the case with those that had been previously run at 12.4 ewes/ha.

Table 13

Weight of sheep 12 months after weaning (kg)

	Year									
	1959			1960			1961			Means
Stocking rate (ewes/ha)	3.7	7.4	12.4	3.7	7.4	12.4	3.7	7.4	12.4	
Lambing time Autumn	40.9	40.4	32.9	41.4	39.0	37.9	38.2	35.0	32.6	37.6
Winter	40.9	42.7	33.6	46.5	48.5	44.0	47.2	45.3	43.5	43.6
Spring	42.0	41.3	44.0	45.2	39.4	43.9	40.3	39.4	40.5	41.8
Mean	41.2	41.5	36.8	44.4	42.3	42.0	41.9	39.9	39.9	

Means for stocking rates—3.7 ewes/ha: 42.5 7.4 ewes/ha: 41.2 12.4 ewes/ha: 39.2

The growth of the weaners in relation to age is shown in figure 7. This shows that in each year of the experiment the mean weight of autumn-born sheep about one year after weaning was lower than that of either the winter or spring-born groups (table 13). This is due to the low weight at weaning of the 12.4 ewes/ha autumn-born group compared with the winter and spring group at the same stocking rate. In 1960/61 the weights of the sheep from the intermediate and high stocking rates one year after weaning did not differ significantly.

In the winter groups, the sheep from the 12.4 ewes/ha did not attain the liveweights of the former 3.7 and 7.4 ewes/ha sheep.

The spring-born lambs from the 12.4 ewes/ha treatment grew as well as those from 3.7 ewes/ha, showing that the satisfactory growth up to weaning was maintained in the post-weaning phase. This contrasted with the autumn-born sheep from the 12.4 ewes/ha where the pre-weaning nutritional penalty was maintained for at least 12 months after weaning.

Wool production

The mean greasy fleece weights for the hoggets are shown in table 14.

The 1959 autumn-born sheep were shorn without fleece weights being taken. The values given are for a year's growth of wool from sheep run under identical conditions after weaning. However, the values are not strictly comparable because the autumn-born sheep were shorn in September whereas the winter and spring-born sheep were shorn in February. The spring-born weaners were six weeks younger than the winter-born sheep when shorn as hoggets.

Table 14

Effect of time of lambing on wool production from the hoggetts

Lambing time	Year of birth	Mean greasy fleece weight (kg)
Autumn	1959	Not measured
	1960	3.6
	1961	2.9
Winter	1959	5.0
	1960	4.3
	1961	4.6
Spring	1959	4.7
	1960	4.2
	1961	3.7

The mean fleece weight of the autumn group was affected by the previous stocking rate as shown in table 15.

Table 15

Greasy wool production from the autumn-born sheep in relation to the stocking rate of their dams

Year	Previous stocking rate (ewes/ha)	Mean greasy fleece weight (kg)
1960	3.7	4.0[a1]
	7.4	3.6[ab]
	12.4	3.4[b]
1961	3.7	3.6[a]
	7.4	3.2[b]
	12.4	2.6[c]

[1] Means with similar superscripts are not significantly different.

Discussion

Lamb growth

The weights at 4 and 12 weeks for these Merino lambs are comparable with those in the literature, e.g., Dawe (1968) in New South Wales with growth rates ranging from 190 to 220 g/d, Fogarty (1972) with values ranging from 178 g/d at Cowra to 229 g/d at Glen Innes. The growth rates recorded in this experiment varied from 102 to 244 g/d. The gains at the lower stocking rates and the later time of lambing in this study are superior to those reported by Stevenson (1968) for fine wool Merinos on the Southern Tablelands of New South Wales and Sidwell, Everson and Terrill (1964) with Merinos in Washington, United States of America.

In each year, the growth of the autumn-born lambs to 12 weeks of age was markedly affected by stocking rate with this effect being greatest in the difficult years of 1959 and 1962.

There are two qualifications concerning the advantages for growth rate arising from spring lambing at Kojonup. Firstly, any disadvantages of autumn lambing may have been overcome by supplementary feeding of the ewes in late pregnancy. It is significant that supplementary feeding of autumn lambing ewes was not practised in this study, whereas it generally is in commercial farming. Secondly, in areas where there is a risk of an early finish to the season (mid-November or earlier) weaning weight of the spring-born lambs is reduced (table 11) if they are born on or after September 1.

Post-weaning performance

Losses

Nearly all the deaths occurred during the months of December, January and February, and were usually associated with lower weaning weights. Losses amongst light sheep have been commented on previously, e.g. Bennetts (1958), and probably were not due to any deficiency in either the consumption or digestion of roughage diets. The smaller weaners probably have a higher requirement for protein and a smaller store of tissue reserve which could be metabolised to meet the energy deficiencies of the pasture. Thus, smaller weaners have small reserves relative to their mass of metabolically active tissues and so their power of endurance of stress or deprivation is restricted. In addition, a high proportion of the total energy of the body of the smaller weaners is stored as protein which may be less easily catabolised than fat and more difficult to replace under conditions either of nitrogen shortage or when the feed is deficient in energy.

Weaner losses were higher in the autumn born groups than in either winter or spring groups, but most of these losses were in weaners previously run at 12.4 ewes/ha.

Growth rate

Allden (1968a, b and c) has examined and discussed the undernutrition of the Merino sheep pre- and post-weaning and its sequelae. Those studies are particularly relevant to the present investigation. Allden showed that the effect of retarded growth during the first six months of life persisted for a further 5-6 months. In the investigation reported here, the effect of pre-weaning nutritional penalty induced by lambing time and stocking rate is continued for 12 months.

The mean weight at 15 months of age of the autumn-born sheep was lower than that of either the winter or spring groups. This was due particularly to the consistently lighter weight at weaning of the autumn-born lambs from 12.4 ewes/ha group, compared with the higher weaning weights of the lambs of the 12.4 ewes/ha groups in the winter and spring groups.

In the autumn and winter groups the previous stocking rate often affected post-weaning growth, but there was no effect of stocking rate on the post-weaning growth of the spring-born lambs.

Wool production

Lightfoot (1967) showed that time of shearing affects greasy wool production so that it is not valid to compare the wool production of the spring-born sheep with that of the other two lambing times. The mean wool production of the autumn-born group was affected by the reduced wool production of the sheep which had been previously run at 12.4 ewes/ha.

Winter lambing appeared to give the highest wool production per head—most probably because of the combination of a good plane of nutrition pre-natally, plus at least four months on green feed after lambing.

Figure 4A(1). Lamb growth in relation to age – autumn-born – 1959

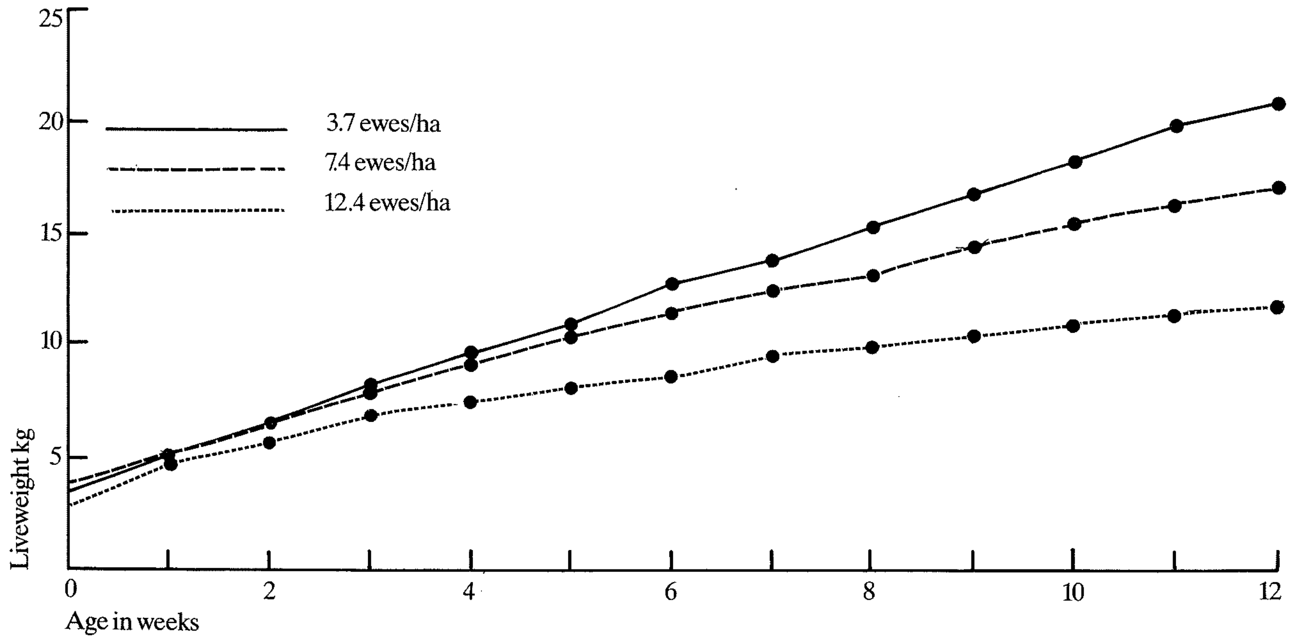


Figure 4A(2). Lamb growth in relation to age – autumn-born – 1960

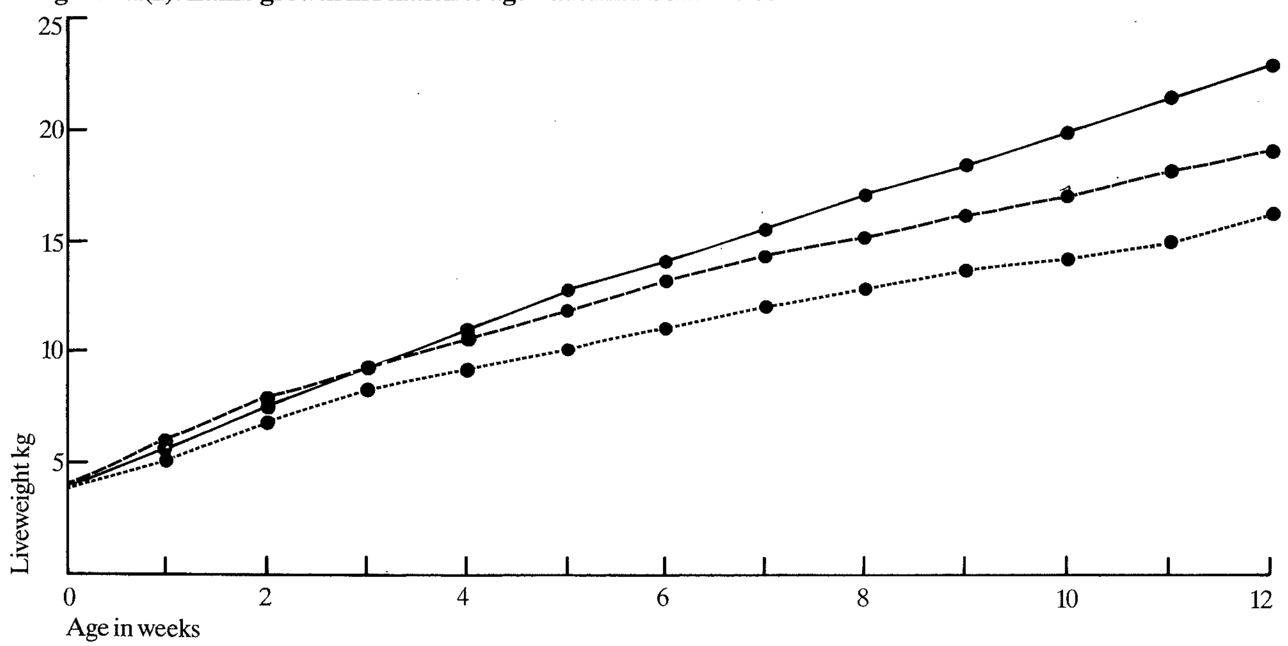


Figure 4A(3). Lamb growth in relation to age – autumn-born – 1961

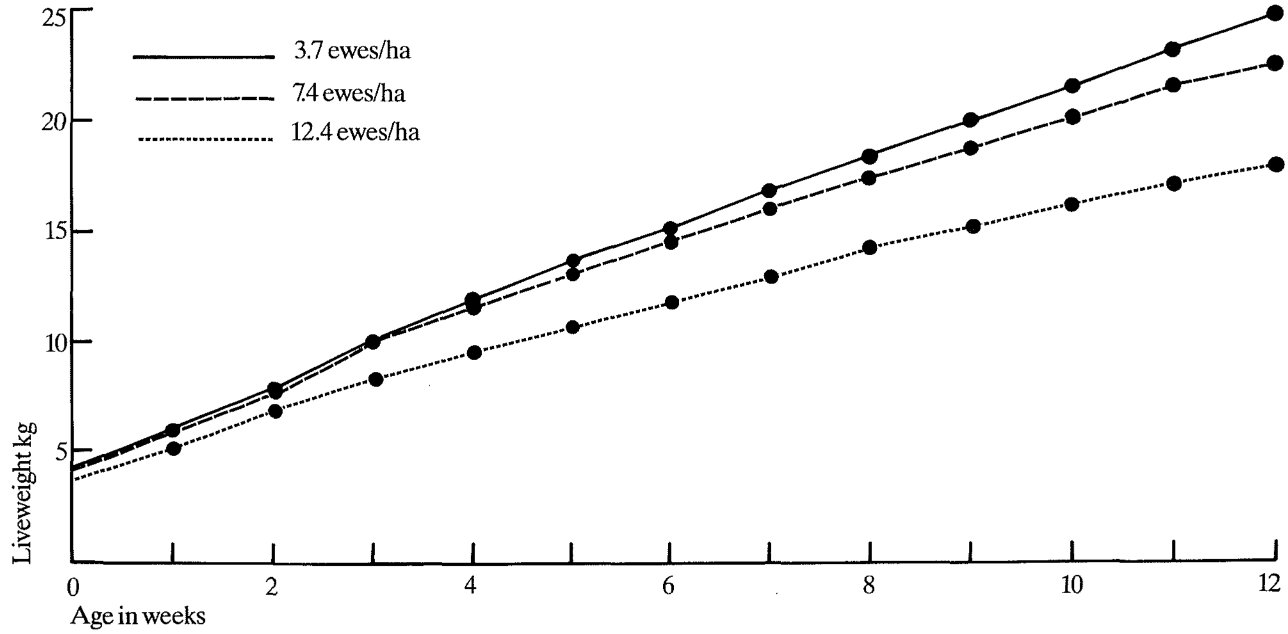


Figure 4A(4). Lamb growth in relation to age – autumn-born 1962

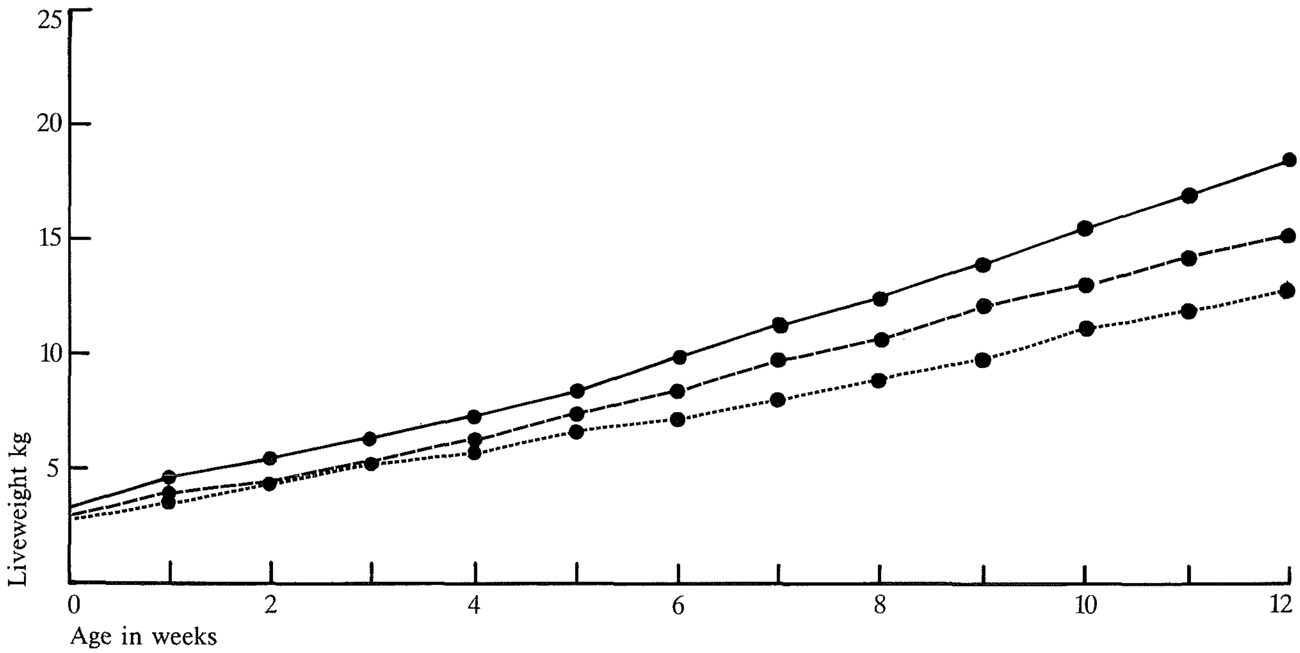


Figure 4B(1). Lamb growth in relation to age – winter-born – 1959

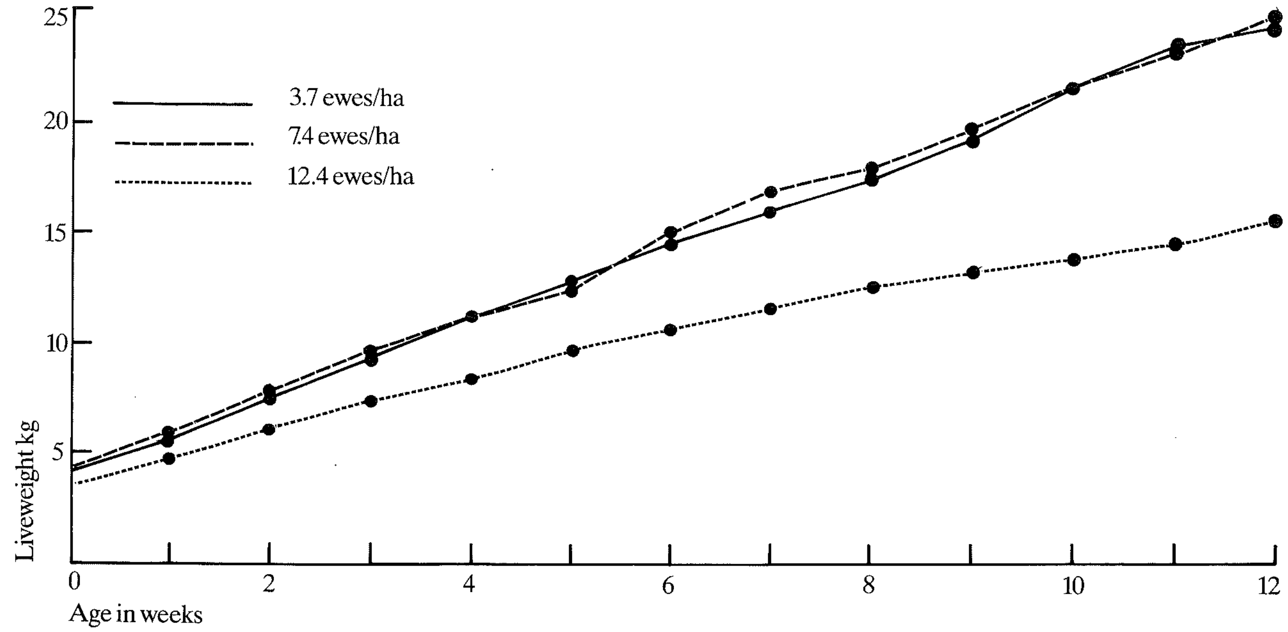


Figure 4B(2). Lamb growth in relation to age – winter-born – 1960

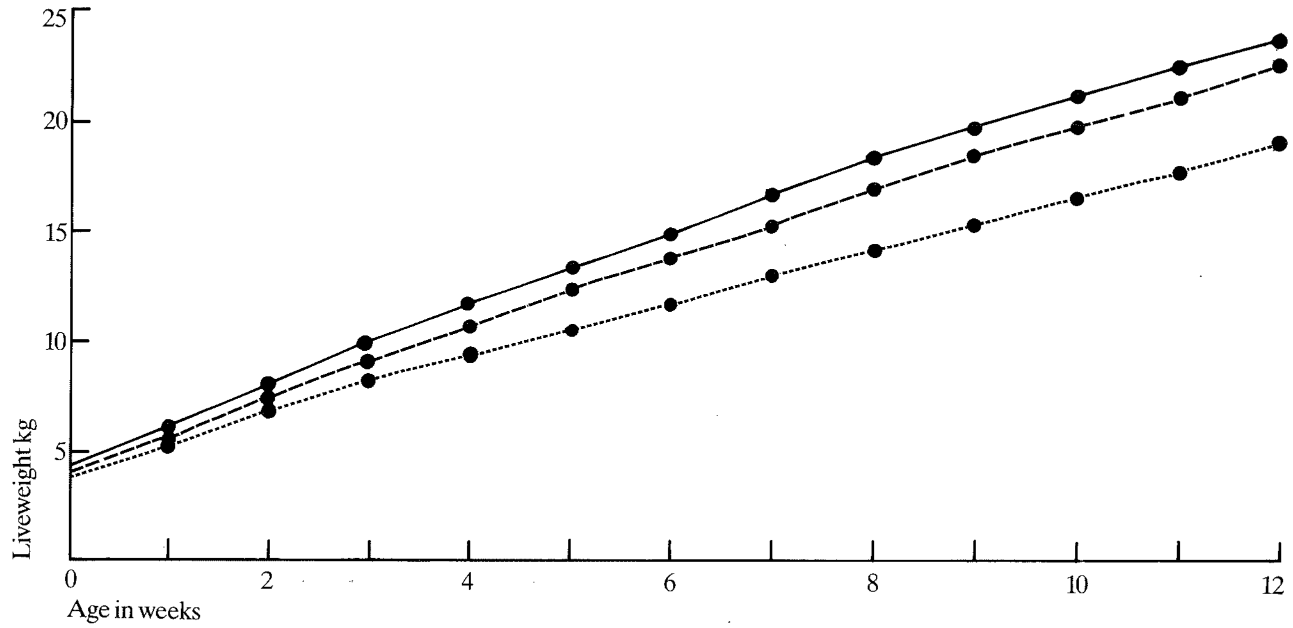


Figure 4B(3). Lamb growth in relation to age – winter-born – 1961

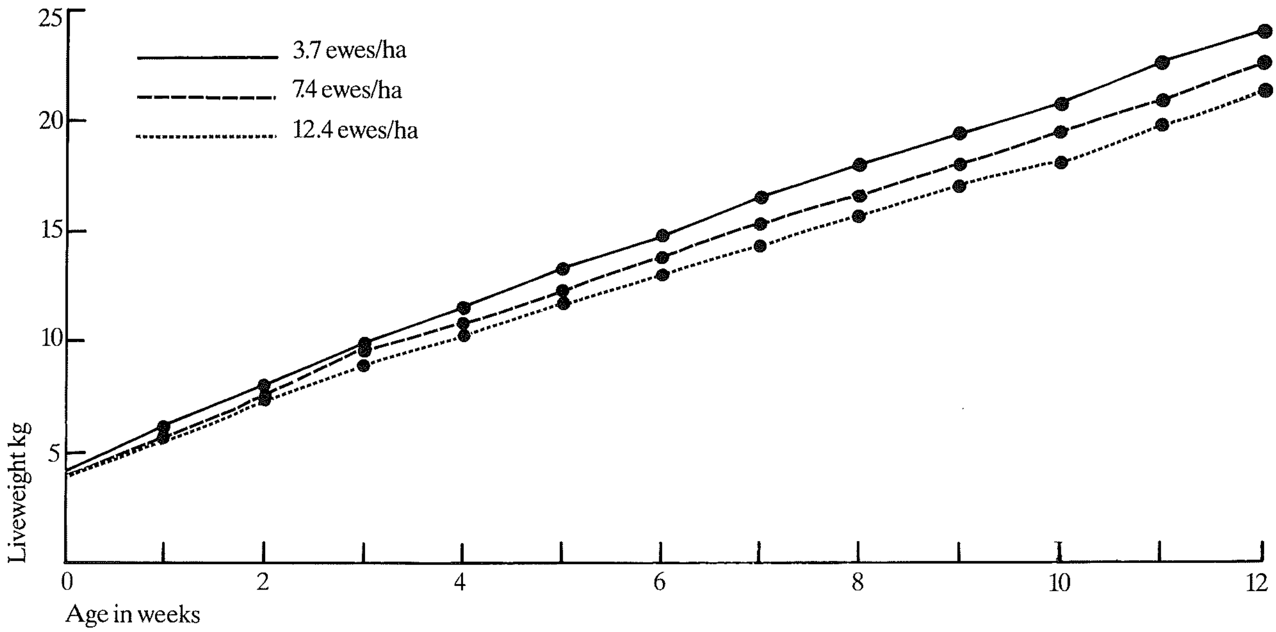


Figure 4B(4). Lamb growth in relation to age – winter-born – 1962

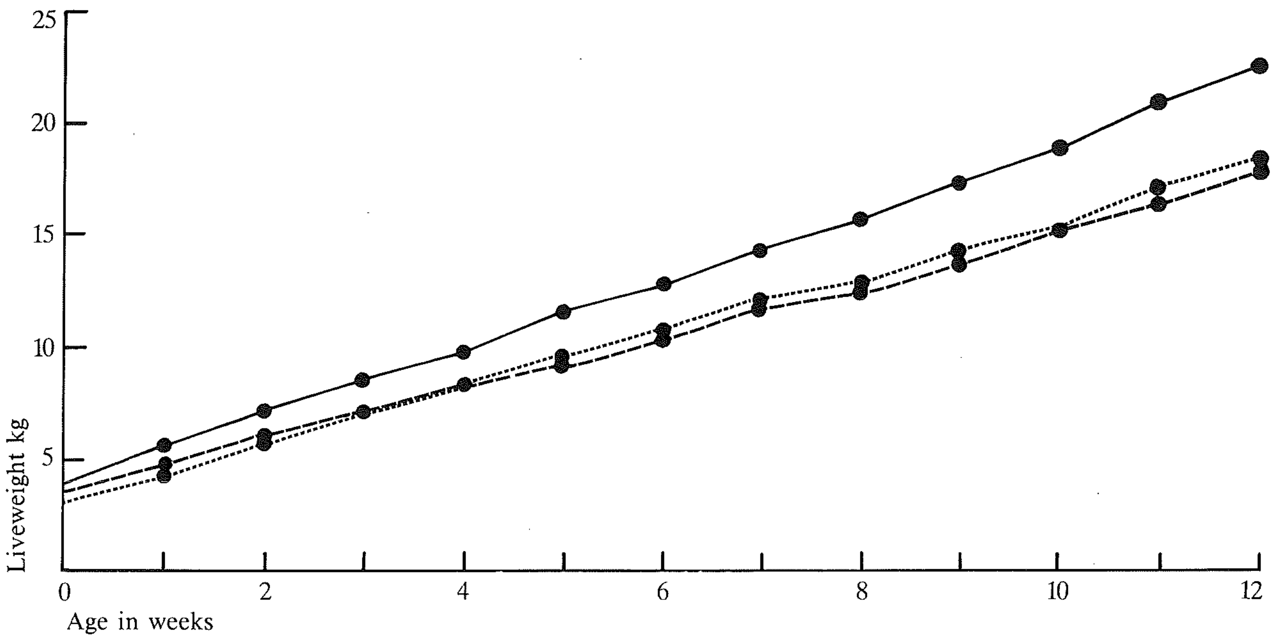


Figure 4C(1). Lamb growth in relation to age – spring-born – 1959

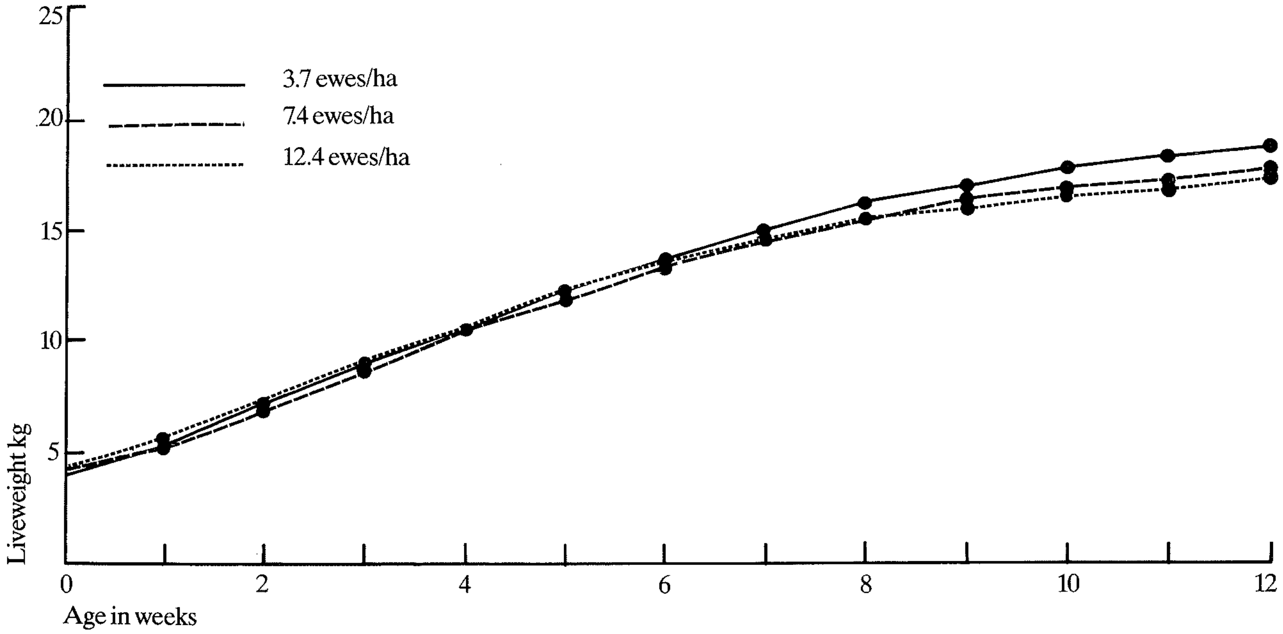


Figure 4C(2). Lamb growth in relation to age – spring-born – 1960

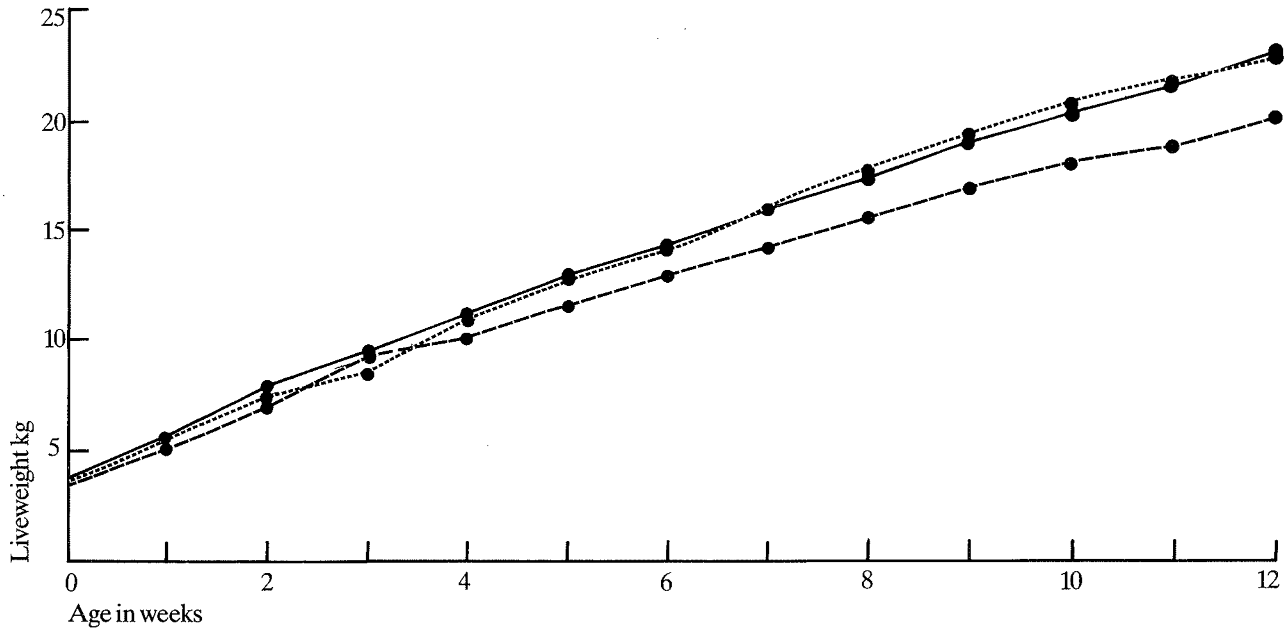


Figure 4C(3). Lamb growth in relation to age – spring-born – 1961

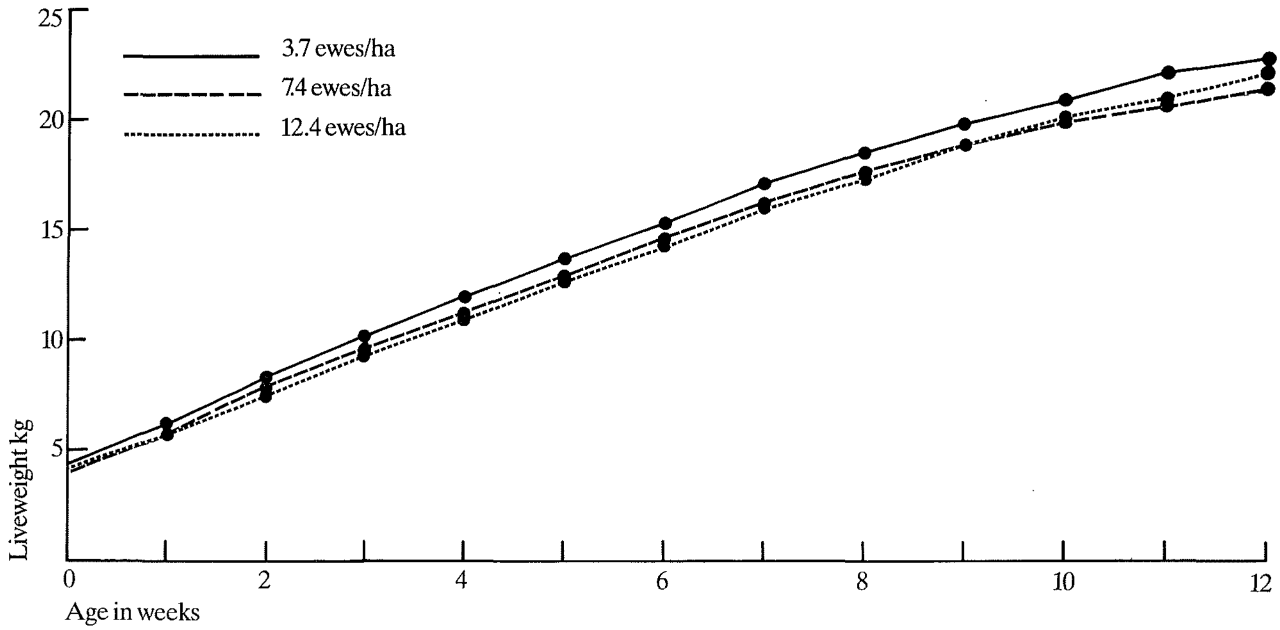


Figure 4C(4). Lamb growth in relation to age – spring-born – 1962

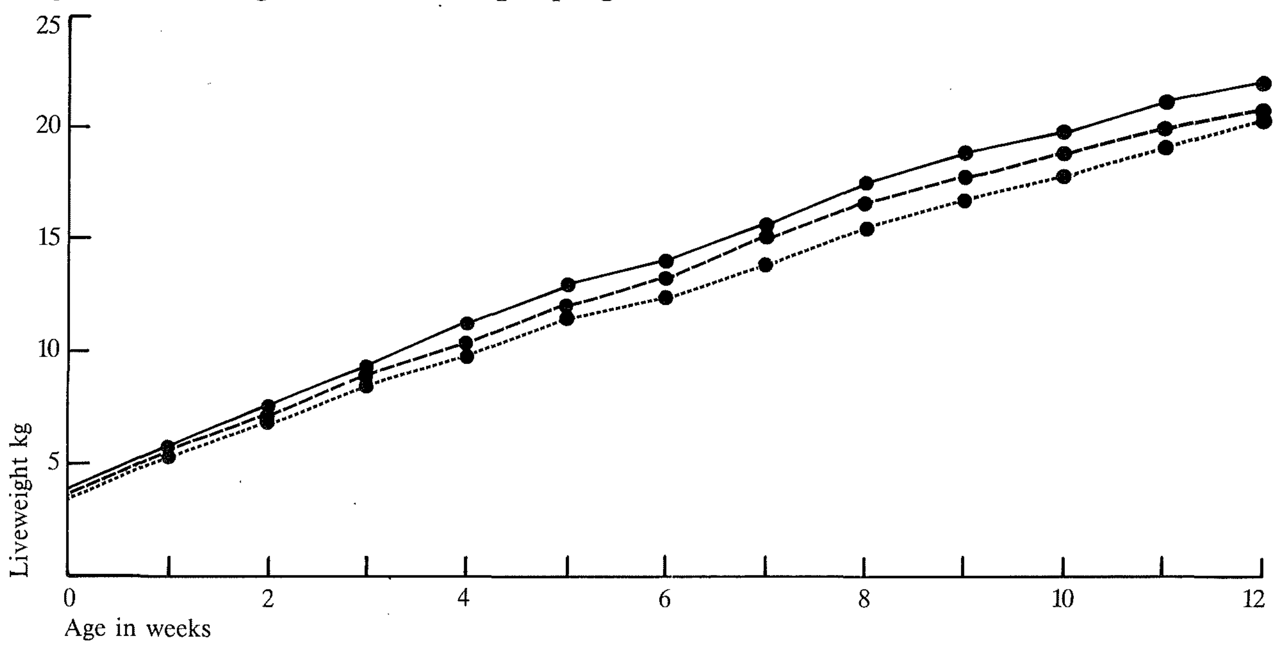


Figure 5A. The effect of stocking rate and lambing time upon weight of lambs weaned/ha – 1959

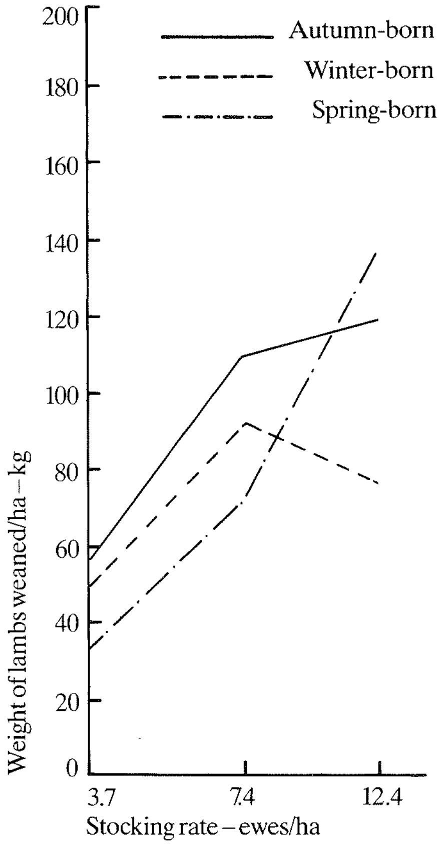


Figure 5B. The effect of stocking rate and lambing time upon weight of lambs weaned/ha – 1960

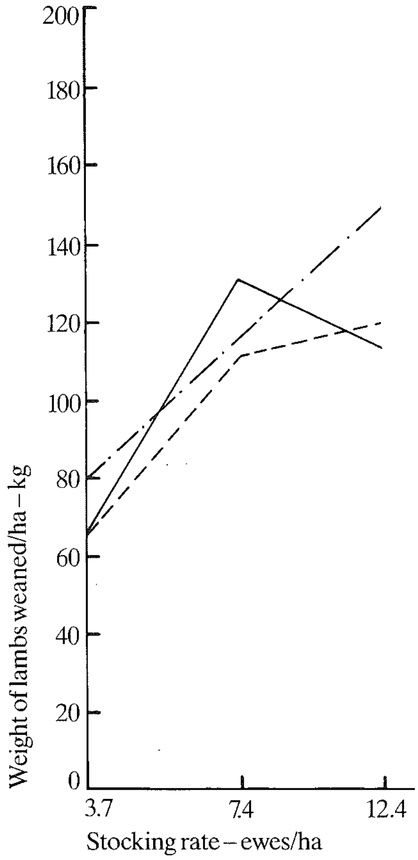


Figure 5C. The effect of stocking rate and lambing time upon weight of lambs weaned/ha – 1961

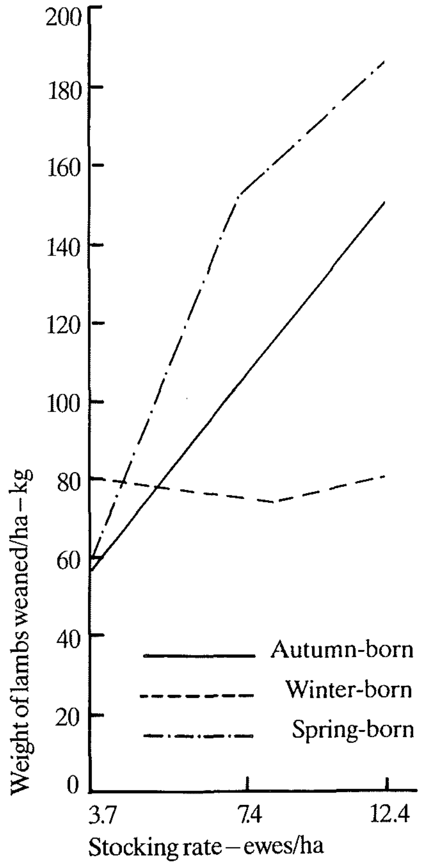


Figure 5D. The effect of stocking rate and lambing time upon weight of lambs weaned/ha – 1962

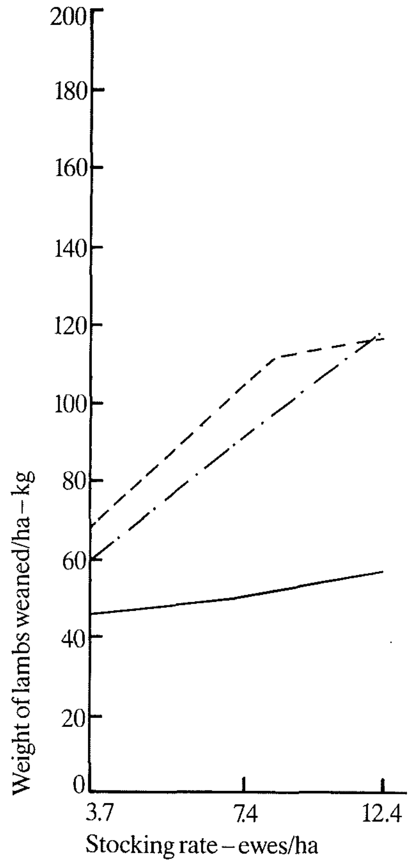


Figure 6A(1). Liveweight change of weaners – lambing time × stocking rate experiment – autumn-born – 1959

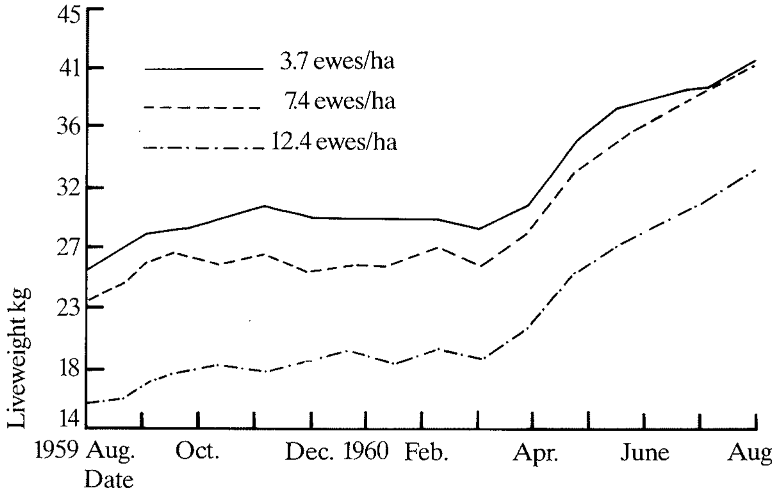


Figure 6A(2). Liveweight change of weaners – lambing time × stocking rate experiment – winter-born – 1959

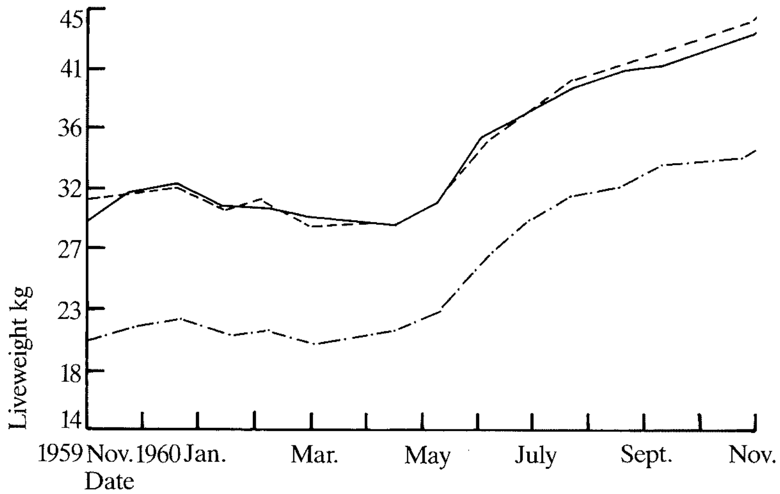


Figure 6A(3). Liveweight change of weaners – lambing time × stocking rate experiment – spring-born – 1959

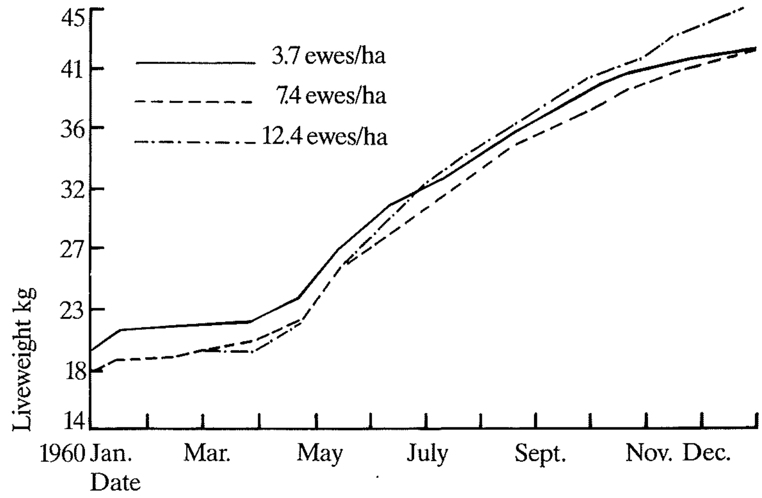


Figure 6B(1). Liveweight change of weaners – lambing time × stocking rate experiment – autumn-born – 1960

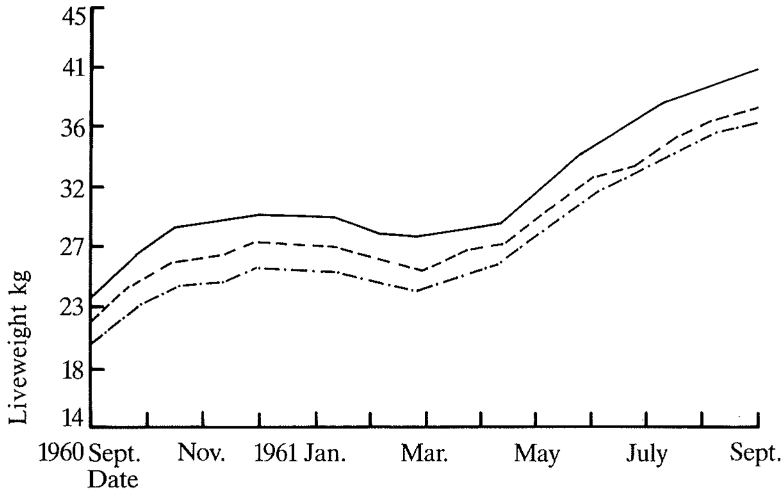


Figure 6B(2). Liveweight change of weaners – lambing time × stocking rate experiment – winter-born – 1960

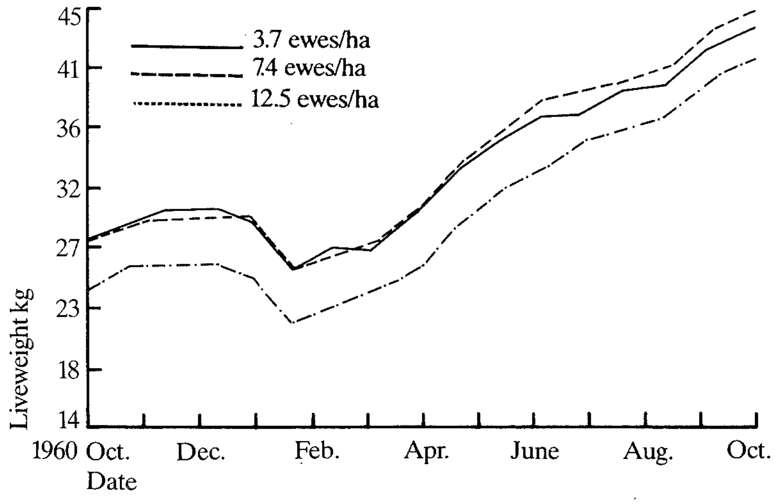


Figure 6B(3). Liveweight change of weaners – lambing time × stocking rate experiment – spring-born – 1960

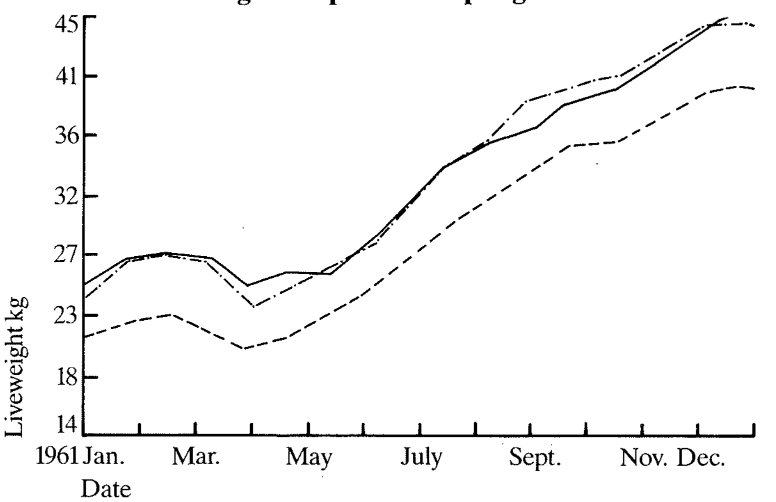


Figure 6C(1). Liveweight change of weaners – lambing time × stocking rate experiment – autumn-born – 1961

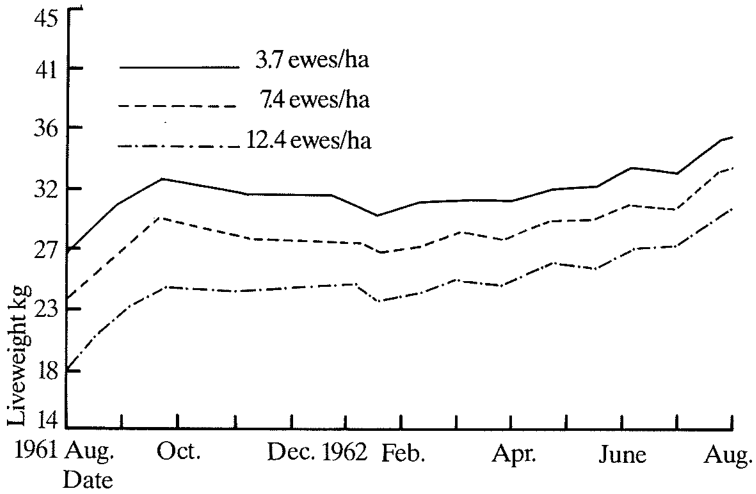


Figure 6C(2). Liveweight change of weaners – lambing time × stocking rate experiment – winter-born – 1961

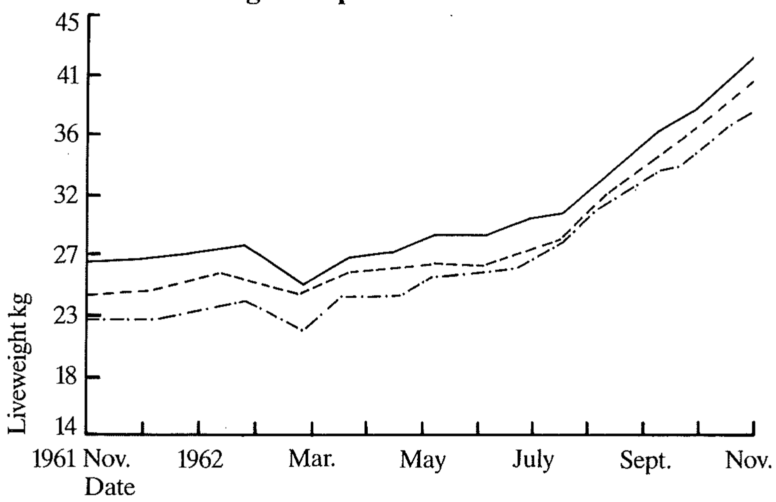


Figure 6C(3). Liveweight change of weaners – lambing time × stocking rate experiment – spring-born – 1961

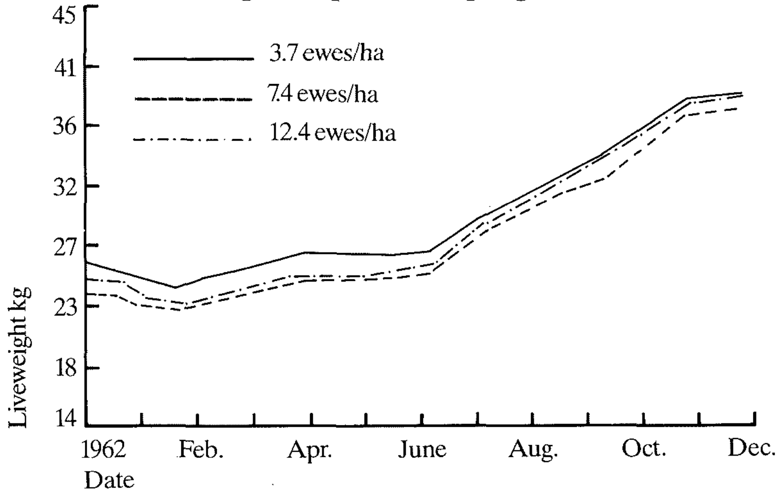


Figure 7A. Growth of weaners in relation to age – born 1959

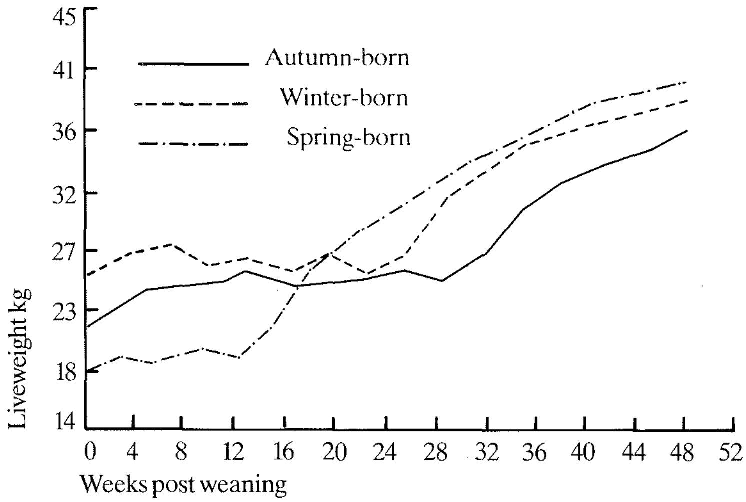


Figure 7B. Growth of weaners in relation to age – born 1960

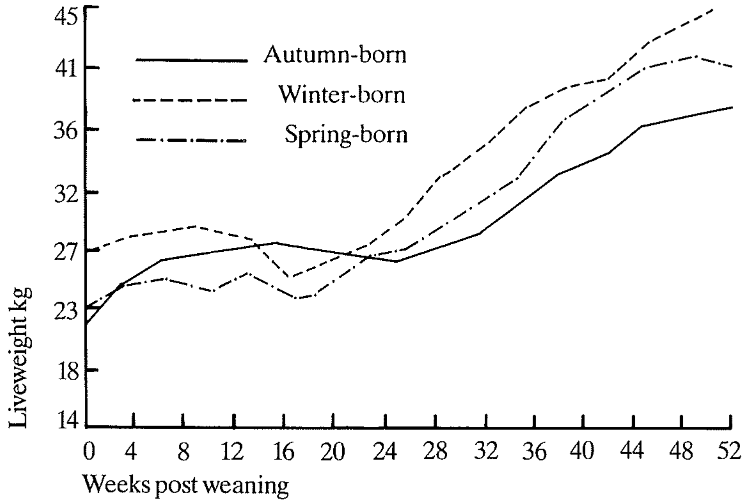
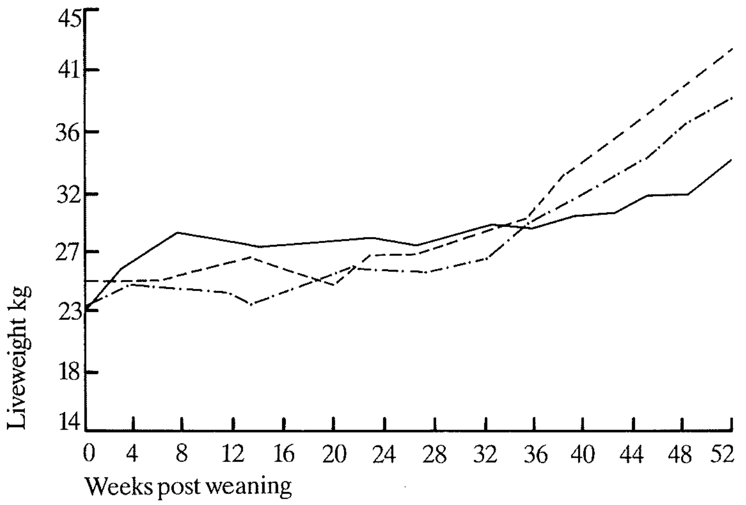


Figure 7C. Growth of weaners in relation to age – born 1961



Part 4—Wool production

Summary

There were highly significant effects of year on fleece weights with production in 1962 being significantly lower than in 1960 and 1961. Comparisons of wool production for spring lambing ewes with those for ewes lambing in autumn and winter were precluded by differences in the times of shearing.

There were no significant differences in either greasy or clean wool cut per head between autumn and winter in ewes grazed at the same stocking rate.

Stocking rate significantly reduced greasy wool cut per head with the reduction being greater at 12.4 ewes/ha (3.7 ewes/ha—4.2 kg; 7.4 ewes/ha—4.0 kg and 12.4 ewes/ha—3.7 kg). The mean greasy wool production per hectare for autumn and winter lambing was: 3.7 ewes/ha—16.0 kg; 7.4 ewes/ha—30.4 kg; 12.7 ewes/ha—46.7 kg while the figures for spring lambing (the data refers only to 1961 and 1962) were: 3.7 ewes/ha—15.5 kg; 7.4 ewes/ha—31.7 kg and 12.4 ewes/ha—53.5 kg.

Time of lambing affected the proportion of tender fleeces—18.2% of autumn lambing ewes had tender fleeces compared with 5.3% of winter lambing ewes and 1.8% of spring lambing ewes. There were more tender fleeces (13.5%) from the 12.4 ewes/ha group than the 7.4 (5.8%) and 3.7 ewes/ha (10.6%) groups.

Introduction

Wool production per hectare is a major factor determining the profitability of a sheep flock. In this study, unexpected problems arose in measuring the effect of time of lambing and stocking rate on wool production associated with the two factors. Firstly, shearing and spring lambing coincided in the first year, leading to increased lamb losses through mis-mothering. Consequently, the time of shearing of the spring ewes was changed to autumn in subsequent years. Secondly, with a breeding flock, there are at least six "physiological" classes of ewes, *viz.*

- Twin bearing ewes raising 2 lambs
- Twin bearing ewes raising 1 lamb
- Twin bearing ewes raising 0 lambs
- Single bearing ewes raising 1 lamb
- Single bearing ewes raising 0 lambs
- Barren ewes

Valid comparisons between the autumn and winter groups for measuring the effect of lambing time and stocking rate on wool production are possible, but neither can be compared with the spring lambing group. The physiological groups with adequate numbers for valid statistical comparisons (analysis of variance on plot means) were uniparous ewes which reared one lamb and barren ewes.

Materials and methods

The greasy fleece weight was that of the unskirted fleece and the belly wool. A mid-side sample was taken from each fleece. These samples were scoured initially with a commercial detergent (Teepol) and then extracted with ether to remove any lipids. An attempt was made to remove obvious vegetable matter by plucking burrs out with forceps. The clean wool results were expressed on a clean 'dry' basis. No allowance was made for moisture regained. Tenderness was measured by manually applying a force of an estimated 20 N/ktex to the staple and if the staple parted, the fleece was classified as tender.

Results and discussion

Time of lambing

As mentioned in the introduction, the only groups of ewes with adequate numbers for statistical analysis were:

- Uniparous ewes which reared one lamb
- Barren ewes

1. Autumn and winter groups

The effect of lambing time upon the greasy and clean fleece weights of these groups is shown in table 16.

(a) "Wet" ewes
"Wet" ewes in this context are the uniparous ewes which raised a lamb. There were no statistically significant differences in mean greasy or clean wool production per head between the autumn and winter groups at the same stocking rate. There were however, large and significant differences in wool production between years, particularly between 1962 and the two previous years, which reflected the difference in amount and incidence of rain. In each year, the winter group at 12.4/ha cut less greasy wool per head than those of the autumn group at the same stocking rate (table 16). Since the sheep were not randomised in relation to wool production at the start of the experiment, and there were only 38 ewes in the winter

Table 16

Mean wool production of "Wet" (ewes rearing 1 lamb) and barren ewes lambing in autumn and winter

Year	Lambing time	Stocking rate ewes/ha	Wet ewes Greasy kg/hd	Wet ewes Clean kg/hd	Barren ewes Greasy kg/hd	Barren ewes Clean kg/hd	All ewes Greasy kg/hd	All ewes Clean kg/hd	Wool production Greasy kg/ha	Wool production Clean kg/ha
1960	Autumn	3.7	4.8 *	2.7	4.8 **	2.8	4.8 *	2.7	17.8	10.1
		7.4	4.2 **	2.6 * **	4.3	2.6 ** **	4.3 **	2.6 *	31.6	19.2
		12.4	3.9	2.3 *	3.7 **	2.3 **	3.9 *	2.4	47.9	30.4
	Winter	3.7	4.7 *	2.9 **	5.2 *	3.3 *	4.8 *	3.0 *	17.7	10.0
		7.4	4.3 ***	2.5 ***	4.6	3.0 ***	4.4 **	2.6 **	32.6	19.0
		12.4	3.8 **	2.4	4.1 *	2.7 *	3.9 *	2.4	48.4	29.9
1961	Autumn	3.7	4.3	2.7	4.5 **	2.8 *	4.4	2.8	16.4	10.2
		7.4	4.3	2.7	5.0	3.1	4.5 *	2.7	33.3	20.3
		12.4	4.1	2.5	4.2 **	2.7 **	4.1	2.6	50.5	31.7
	Winter	3.7	4.4	2.9	4.8	3.0	4.5	2.8	16.5	10.6
		7.4	4.4 * *	2.7	4.7	3.0	4.4	2.7 *	32.4	20.2
		12.4	4.0	2.4	4.6	2.8	4.2	2.5	52.0	31.2
1962	Autumn	3.7	3.7 *	2.2	3.8	2.3	3.7	2.3	13.7	8.4
		7.4	3.3 **	2.1 *	3.5	2.2 *	3.5 *	2.1 ** ***	25.8	15.5
		12.4	3.2	1.9	3.5	2.0	3.2	1.9	40.3	23.7
	Winter	3.7	3.4	2.2	3.9	2.4	4.3	2.6	15.9	9.6
		7.4	3.4	2.2 * *	3.7 * **	2.4 * *	4.1 *	2.5 *	30.2	18.4
		12.4	3.1	1.8	3.3	2.1	3.7	2.3	46.2	28.5
Three year mean	Autumn	3.7	4.2	2.5	4.2	2.6	4.3	2.6	15.9	9.6
		7.4	4.0 *	2.5 *	4.1 **	2.8 *	4.1 *	2.5 *	30.2	18.4
		12.4	3.8	2.2	3.8	2.4	3.7	2.3	46.2	28.5
	Winter	3.7	4.2	2.6	4.5	2.7	4.3	2.7	15.9	10.0
		7.4	4.0 *	2.0 *	4.3 *	2.6 *	4.1 *	2.5 *	30.3	18.7
		12.4	3.6	2.2	4.0	2.3	3.8	2.3	46.8	28.3

* Group data includes all the ewes, regardless of lambing history, which had been on the treatment for 12 months

LSD for stocking rate means

	Greasy wool weight (kg)	Clean wool weight (kg)
* P < 0.05	0.37	0.23
** P < 0.01	0.50	0.31
*** P < 0.001	0.67	0.41

group which gave birth and reared one lamb, and were on the plots for 12 months, small differences need not necessarily be ascribed to a lambing time effect.

(b) Barren ewes
The barren ewes from the winter groups cut significantly more wool per head than the barren ewes in the autumn groups at each stocking rate. In most cases, greasy wool production per head from the barren ewes was greater than for wet ewes. Some of the difference between the two times of lambing for the barren ewes may have been due to the extra grazing pressure imposed by the greater consumption of the ewes and lambs in the autumn group in the critical autumn period.

2. Spring group

Details of wool production for the spring lambing ewes which were shorn at a different time from the autumn and winter groups are given in table 17.

Although the greasy fleece production per head was identical at the lowest stocking rate each year, the effect of the difficult 1962 season is manifested in the significant differences at the two higher stocking rates, both for greasy and clean fleece weights. The difference in greasy wool production per head between barren ewes and those that had given birth to and reared a lamb (mean for all stocking rates) was 0.59 kg ($P < 0.01$).

The effect of stocking rate

There was a marked increase in wool production per hectare with increasing stocking rate. On three occasions, over 50 kg of greasy wool per hectare was produced at the highest stocking rate (tables 16 and 17). The highest wool production per hectare was achieved with spring lambing at 12.4 ewes/ha in 1961 (58.3 kg/ha greasy : 38.8 kg/ha clean).

1. Autumn and winter group

In the autumn and winter groups (table 16), wool production per head decreased with increasing stocking rate in two of the three seasons. In the season that this did not occur (1961), the wool production per head of 12.4 ewes/ha was significantly ($P < 0.05$) lower than that of the sheep grazed at 3.7 and 7.4 ewes/ha. Over the three year period, there was virtually no difference between autumn and winter lambing in the effect of stocking rate upon mean greasy wool production per head.

2. Spring group

Only two seasons were available for assessing the effect of stocking rate on wool cut per head. In the first season (1961) increasing stocking rate did not reduce wool production per head. Wool production per hectare was highest in the 12.4 ewes/ha group (see table 17).

Table 17

Wool production of spring lambing ewes

Year	Stocking rate (ewes/ha)	Wet ewes Greasy (kg/hd)	Wet ewes Clean (kg/hd)	Barren ewes Greasy (kg/hd)	Barren ewes Clean (kg/hd)	All ewes Greasy (kg/hd)	All ewes Clean (kg/hd)	Wool production Greasy (kg/ha)	Wool production Clean (kg/ha)
1961	3.7	4.1	2.6	4.5	3.0	4.1	2.7	15.2	9.8
	7.4	4.4 }* }*	3.0 }* }***	4.8 }*	3.2 }*	4.6 }* }**	3.0 }* }*	33.7	22.5
	12.4	4.6	3.0	4.6	3.1	4.7	3.1	58.3	38.8
1962	3.7	4.1	2.3	5.0	2.8	4.2	2.4	15.7	8.9
	7.4	3.9 }*	2.3	4.7 }**	2.7 }**	4.0	2.3	29.5	17.8
	12.4	3.7	2.2	4.3	2.5	4.0	2.3	49.2	29.0
Two year mean	3.9	4.1	2.5	4.9	2.8	4.2	2.5	15.5	9.4
	7.4	4.1	2.6	4.7	2.9	4.3	2.7	31.7	19.8
	12.4	4.0	2.5	4.4	2.7	4.3	2.7	53.5	33.8

LSD for comparisons between stocking rates

	Greasy wool weight (kg)	Clean wool weight (kg)
* $P < 0.05$	0.29	0.18
** $P < 0.01$	0.41	0.25
*** $P < 0.001$	0.55	0.34

Table 18
Mean wool production (kg) per head in relation to the number of lambs born and reared by the ewes

Stocking rate (ewes/ha)	Lambing time	Year	2 reared 2		2 reared 1		2 reared 0		1 reared 1		1 reared 0		Barren ewes	
			No. of ewes	Mean wool wt (kg)	No. of ewes	Mean wool wt (kg)	No. of ewes	Mean wool wt (kg)	No. of ewes	Mean wool wt (kg)	No. of ewes	Mean wool wt (kg)	No. of ewes	Mean wool wt (kg)
3.7	Autumn	1960, 1961, 1962	2	4.2	—	—	1	7.0	58	4.2	14	3.8	28	4.3
	Winter	1960, 1961, 1962	3	4.2	3	3.5	1	4.3	67	4.2	8	4.4	39	4.6
	Spring	— , 1961, 1962	2	3.8	1	4.2	—	—	39	4.1	8	4.5	8	4.9
7.4	Autumn	1960, 1961, 1962	—	—	1	4.2	2	3.5	68	4.1	12	4.1	35	4.2
	Winter	1960, 1961, 1962	7	4.0	6	3.9	2	3.5	42	4.0	24	4.1	40	4.4
	Spring	— , 1961, 1962	3	3.7	—	—	—	—	41	4.1	6	4.4	8	4.7
12.4	Autumn	1960, 1961, 1962	2	4.2	3	3.9	—	—	48	3.8	20	3.6	45	3.8
	Winter	1960, 1961, 1962	3	3.8	4	3.4	1	3.0	38	3.6	19	3.6	49	4.0
	Spring	— , 1961, 1962	—	—	—	—	—	—	32	4.0	8	4.0	12	4.4
Total number of ewes and mean wool production			22	4.0	18	3.8	7	4.3	433	4.0	119	4.0	264	4.2

In 1962, although wool cut per head was reduced as stocking rate increased for the wet ewes, the only significant difference ($P < 0.01$) was between 3.7 and 12.4 ewes/ha.

Despite having to compare wool production at different times of shearing and the loss of the first year's data, there are indications from the spring group that stocking rate had a less depressing effect upon wool production per head than with either autumn or winter lambing. This is reflected in the fact that the highest wool production per hectare was from the spring groups at 12.4 ewes/ha.

Effect of pregnancy and lactation on wool production

The numbers of sheep available to investigate the effect of pregnancy and lactation were too small and unevenly distributed for valid statistical examination. Data for each physiological classification are given in table 18.

The difference in wool production between the barren ewes and those that had borne and reared one lamb was 182 g greasy, a difference of 8.5%, which is much lower than the difference usually quoted for the effect of pregnancy and lactation upon wool production (Jones *et al.* 1944; Coop 1950; Story and Ross 1960; Doney and Smith 1961). The treatments in which the differences in wool production between barren and wet ewes were small were the autumn groups at 3.7 and 7.4 ewes/ha.

Table 19

The effect of physiological classification and stocking rate upon greasy wool production (kg)

Stocking rate: (ewes/ha)	3.7	7.4	12.4	Mean
Class				
1 reared 1	4.2	4.0	3.8	4.0
1 reared 0	4.1	4.1	3.7	4.0
Barren ewes	4.5	4.3	3.9	4.2
Mean	4.3	4.1	3.8	

LSD
$P<0.05$ 0.24; $P<0.01$ 0.39; $P<0.001$ 0.73

A surprising result was the lack of a difference between the ewes which had borne and reared one lamb, and uniparous ewes which lost their lambs neo-natally. A possible explanation of this is that neo-natal mortality is often associated with maternal nutritional stress—thus, the same stress which led to the lamb loss could have depressed wool production.

The effect of stocking rate, which was the only treatment of any significance, upon the physiological classes where valid comparisons can be made is shown in table 19.

The effect of stocking rate was only significant between 3.7 and 12.4 ewes/ha for the 1 born, 1 reared class. The differences between 7.4 and 12.4 ewes/ha was significant for the 1 born, 0 reared class.

Wool quality

The only wool quality measurements made in this study were clean yield and tenderness (measured subjectively). There were no consistent trends in the effects of either stocking rate or time of lambing upon the proportion of clean wool.

The number of tender fleeces in relation to stocking rate and lambing time is shown in table 20. There were far more tender fleeces with autumn ($P<0.01$) than with either winter or spring lambing. The differences between the winter and spring groups were not statistically significant.

The effect of stocking rate upon the proportion of tender fleeces was not consistent. In autumn, there was a relatively high proportion of tender fleeces (14-24%) at all stocking rates whereas in winter only at 12.4 ewes/ha was there a high proportion of tender fleeces (14%). With spring lambing the proportion of tender fleeces was negligible.

Table 20

The incidence of tender fleeces

Lambing time	Stocking rate: (ewes/ha) 3.7		7.4		12.4		Total	
	No.	%	No.	%	No.	%	No.	%
Autumn	25	24.3	17	14.3	22	18.5	64	18.2
Winter	3	2.5	0	0.0	16	13.9	19	5.3
Spring	2	3.4	1	1.7	0	0.0	3	1.8
Total	30	10.6	18	5.8	38	13.3	86	12.1

Part 5—Pasture production and composition

Summary

The amount of pasture on offer at the end of the growing season (late October) ranged from 3 600 kg/ha at the low stocking rate to 2 300 kg/ha at the high rate. There was often less than 1 500 kg pasture/ha at 7.4 and 12.4 ewes/ha in the critical months of April and July.

Stocking rate was the most important variable affecting botanical composition. In October the proportion of grasses was 84% at 3.7 ewes/ha, 65% at 7.4 ewes/ha and 40% at 12.4 ewes/ha. This was accompanied by an increase in the proportion of capeweed and erodium as stocking rate increased. The proportion of subterranean clover in October was low and apparently unaffected by stocking rate (3.7 ewes/ha—7.8%; 7.4 ewes/ha—8.2% and 12.4 ewes/ha—7.5%). The proportion of dicotyledonous species was always greater in July than in October.

Introduction

There is little published information on the ecology of the annual pastures of south-western Australia. Rossiter (1964) has discussed the effect of phosphate supply on the growth and botanical composition of an ungrazed annual type pasture and the same author (Rossiter 1966) has given an excellent account of the ecology of Mediterranean pastures.

In this experiment, pasture production and composition were measured to assess whether the low lamb marking percentages were associated with either an inadequate amount of pasture available at critically important times, e.g. mating and lambing, or whether it was associated with the oestrogenic subterranean clover in the pastures.

Material and methods

The botanical composition of the winter and spring lambing plots in July, 1959, was subterranean clover 8.3%, capeweed and erodium 8.7% and grass 82.8%. The autumn lambing treatment is omitted because, by July 1959, the autumn groups had not been on the plots long enough for stocking rates to affect botanical composition.

Subterranean clover made only a small contribution to the species on offer at the beginning of the experiment. An exception was one plot (one replicate of spring lambing at 12.4 ewes/ha) where there was 43% clover. None of the plots were considered likely to produce "subterranean clover disease" in sheep, although subsequent investigations by the author into the effect of the proportion of oestrogenic clover on sheep fertility (Davies and Maller 1970) showed that as little as 30% clover reduces fertility.

Pasture production was estimated by cutting twelve 1 m x 0.5 m quadrats to ground level with a transportable sheep shearing handpiece (Moore, Barrie and Kipps 1946). Under this system, yields of about 1 000 kg/ha indicate a pasture height in a mixed sward of about 2 cm.

Botanical composition of the plots was determined by carrying out a complete hand separation of a sub-sample for the whole plot. This was done on the July samples for each year and on the October samples of 1960, 1961 and 1962. All results for yield and botanical composition are expressed on a dry matter (DM) basis.

Statistical analysis

The yields for January, April, July and October were analysed by analysis of variance for the effect of year, blocks, lambing time and stocking rate and all possible interactions. Interactions were rarely significant.

Botanical compositions of the pastures was analysed by analysis of variance following angular transformation of the proportions of species present.

Results

The yields are the amounts of herbage available to the sheep at four times of the year—January, April, July and October. No allowance has been made for the amount removed by consumption.

The effect of stocking rate on herbage available at different times of each year of the experiment is shown in table 21. Lambing time is omitted as a variable because the effect was satistically significant once only in contrast with the consistently large effect of stocking rate.

The relatively low quantity of dry matter available to the 12.4 ewes/ha group in April and July (table 21) emphasised the hazards of autumn and winter lambing at the highest stocking rates in an unsupplemented flock. From early August to mid-October, pasture growth under grazing in the Kojonup environment would be greater than 10 kg dry matter/ha.d (Greenwood, Davies and Watson 1967) and may be as high as 100 kg/ha.d. From August onward, pasture growth would usually be greater than the sheep's requirements even at 12.4 ewes/ha which should ensure an adequate plane of nutrition for both pregnant and lactating ewes.

Table 21

The effect of stocking rate upon total herbage dry matter and green material (dry matter basis) on offer

kg/ha

Year	Stocking rate (ewes/ha)	January Total	January Green	April Total	April Green	July Total	July Green	October Total	October Green
1959	3.7	Not measured		Not measured		2 120	860	4 100 }*	Not separated
	7.4					1 980	870	3 100 }**	
	12.4					2 030	700	2 400 }*	
1960	3.7	3 240 }*		2 930 }*	660	3 020 }*	1 745	3 130	All green
	7.4	2 100 }*	* Nil	2 620 }*	* 940	1 980 }*	* 1 370	2 730 }*	
	12.4	1 990		1 864	800	1 300	990	2 200	
1961	3.7	2 240 }*		2 520 }*	577	1 800 }*	1 080	3 540	All green
	7.4	1 260 }*	* Nil	1 720 }*	* 721	1 139 }*	* 990	3 010 }*	*
	12.4	1 070		1 200	650	1 340	1 160	2 300 }*	
1962	3.7	2 610 }*		2 240 }*	Not measured (virtually no green)	2 260 }*	640	Not measured	
	7.4	1 760	**Nil	1 360	**	1 810 }*	* 720		
	12.4	1 170 }*		670 }*		1 265	760		
Mean (omitting 1959)†	3.7	2 700 }*		2 560 }*		2 360	1 160	3 690	
	7.4	1 710 }*	* Nil	1 770	**	1 640 }*	1 030	2 950 }*	
	12.4	1 410		1 150 }*		1 300	970	2 300	

* P < 0.05 ** P < 0.01

† October mean is the mean for 1959, 1960 and 1961

The botanical compositions of the pastures are shown in table 22. At the highest stocking rate the proportion of grass was reduced in July, but it is only at 12.4 ewes/ha in 1962 that grasses did not form a high proportion of the species on offer.

There was a higher proportion of dicotyledenous species in July than in October. Stocking rate had little or no effect upon the proportion of clover in July and October.

Table 22

The effect of stocking rate upon botanical composition

(a) July

Year	Stocking rate (ewes/ha)	Grass (%)	Clover (%)	Capeweed (%)	Erodium (%)	Other miscellaneous species (%)
1959	3.7	80.0	10.3	8.9	Not measured separately in 1959 included with capeweed figure	—
	7.4	60.4	19.7	19.9		—
	12.4	57.1	19.9	23.1		—
1960	3.7	59.6	34.5	3.9	2.0	—
	7.4	30.7	43.2	21.0	5.1	—
	12.4	14.7	38.9	31.2	12.9	2.3
1961	3.7	65.4	11.0	11.5	12.1	—
	7.4	51.8	7.5	32.1	6.7	1.9
	12.4	18.2	10.3	50.9	19.4	1.2
1962	3.7	54.0	26.4	12.8	6.8	—
	7.4	37.6	27.8	24.5	10.1	—
	12.4	13.9	16.8	54.5	14.8	—

(b) October

Year	Stocking rate (ewes/ha)	Grass (%)	Clover (%)	Capeweed (%)	Erodium (%)	Other miscellaneous species (%)
1959	3.7	Not measured in 1959				
	7.4					
	12.4					
1960	3.7	89.7	8.6	1.2	0.3	—
	7.4	82.5	12.9	3.2	1.3	—
	12.4	48.2	13.0	26.4	12.3	—
1961	3.7	85.2	4.1	7.1	2.8	0.8
	7.4	74.7	3.6	17.6	3.2	0.9
	12.4	34.7	3.2	43.1	18.3	0.3
1962	3.7	76.6	10.6	7.1	9.1	1.5
	7.4	37.8	8.8	35.5	17.8	0.1
	12.4	18.9	6.4	43.5	31.4	0.3

Chemical composition of the pasture

The nitrogen and ash contents of the individual species in July 1962 are shown in table 23.

Table 23

Chemical composition of the pastures July, 1962

Stocking rate (ewes/ha)	Species	N (%)	Si free ash (%)
3.7	Subterranean clover	3.32	6.88
	Capeweed	2.65	11.85
	Erodium	3.07	9.50
	Grass	3.09	7.38
7.4	Subterranean clover	3.49	7.52
	Capeweed	3.34	7.91
	Erodium	3.72	9.81
	Grass	2.93	7.33
12.4	Subterranean clover	3.60	7.60
	Capeweed	3.47	11.22
	Erodium	3.97	9.11
	Grass	3.62	7.58

These data suggest that both the nitrogen and silica-free ash content of pasture species available in winter were adequate for sheep nutrition.

The phosphorus, calcium, sodium and potassium levels of the pasture in January are shown in table 24.

Table 24

Levels of phosphorus, calcium, sodium and potassium in pasture on offer to sheep in January, 1961

Stocking rate (ewes/ha)	P (%)	K (%)	Na (%)	Ca (%)
3.7	0.10	0.19	0.06	0.6
7.4	0.12	0.19	0.06	0.8
12.5	0.18	0.25	0.07	1.12

The levels of some of these minerals appear to be low, in particular, the phosphate values. There is a possibility that a mineral deficiency, unavailability or imbalance, may have been involved in the sheep infertility which occurred in this experiment.

Daily DM intake of sheep on this type of pasture in summer is probably about 600 g/d (H. E. Fels, personal communication). The sodium and potassium figures in table 24 suggest that such an intake of pasture would provide the daily requirements (A.R.C. 1980) of ewes for these minerals.

Discussion

The DM yields, even at the low stocking rate, suggest that the maximum carrying capacity of these pastures over the summer (about 165 d) would be 12 ewes/ha allowing 1 140 g/head.d for consumption and wastage. This estimate is confirmed by the low liveweight in April of the ewes grazed at 12.4/ha. In a Mediterranean environment, pasture yields at the end of the growing season are probably a reasonable empirical guide to the stock-carrying capacity of the sward.

The pasture production figures in this experiment were low in relation to solar energy, temperature, rainfall and fertilizer applied to the area (c.f. Donald 1951).

The main effect of stocking rate was to increase the proportion of capeweed and erodium ($P < 0.01$). This finding differs from most of the published data on the effect of stocking rate upon botanical composition of temperate mesophytic pastures where increasing stocking rate usually increases the percentage of clover (e.g. Drake and Elliott, 1960). The subterranean clover figures in July of around 24%, regardless of stocking rate, is affected by the figures for 1960 which was the only "good clover year" in the experiment, when, there was more than 34.5% subterranean clover present at all stocking rates. The effect of block and year on proportion of subterranean clover was highly significant.

Experiments carried out by the author (Davies and Maller 1970, Davies and Greenwood 1972) on annual established pastures showed that, when high stocking rates are applied within six months of establishment, clover dominance can be maintained for at least four years.

Capeweed and erodium have obviously an important role in the diet on offer to sheep in the agricultural area of Western Australia.

Although the pasture on offer in July could not be classified as subterranean clover dominant, sheep being de-pastured at a high stocking rate could well be forced to eat

sufficient subterranean clover to give rise to the oestrogenic infertility. Davies and Maller (1970) showed that as little as 30% subterranean clover can be responsible for a significant amount of sheep infertility.

The pasture data indicate that the maximum yields achieved at Kojonup, even under a light stocking rate, were considerably less than potential—certainly less than the potential 8 t/ha suggested by Donald (1951) for Canberra and Black (1955) for Adelaide.

Part 6—Conclusions and practical implications

The author considers that many of the results arising from this investigation of the effects of stocking rate and time of lambing on production from Merino ewes grazing subterranean clover based pastures have important implications for the sheep industry, particularly in the Great Southern statistical areas of south-western Australia. These results and their significance to agricultural advisers, consultants and farm managers in respect of sheep management practices in the 1980s are discussed below.

Flock fertility

The results highlight the generally unsatisfactory lamb marking percentages obtained from Merino ewes throughout this area in the 1960s. It is significant that flock fertility in Western Australia has changed little in the 20 years since this work was completed.

The major cause of infertility was shown to be a combination of ewes failing to conceive (barren ewes), low twinning rates and high levels of perinatal lamb mortality. Failure of ewes to lamb was the most important problem. The results indicated oestrus expression and mating were normal, but it was not possible to determine whether the low conception rates were due to failure of fertilization or embryonic mortality. However, the very low proportion of either abnormally long or short oestrous cycles suggested fertilization failure was probably the more important cause.

Subsequent examination of uteri from the experimental ewes (Davies and Nairn, 1964) suggested that there had been sufficient ingestion of oestrogenic pasture to cause the development of cystic endometrium. This suggestion was subsequently supported (Wroth and Lightfoot 1976) from studies on similar pastures in the Kojonup-Darkan area indicating that fertilization rates among flocks were depressed by some 15% due to clover disease.

The development of pastures based on non-oestrogenic subterranean clovers should ensure that the barren ewe problem will be reduced. For example, Davies, Rossiter and Maller (1970) reported that the proportion of barren ewes in a set-stocked spring lambing system on non-oestrogenic cultivars was only 10% over four years. It is the author's view that although clover breeders have developed a number of cultivars with low formononetin levels in more recent times the production (including fertility) of sheep grazing these clovers has not been adequately assessed.

The effect of stocking rate on flock fertility in the present study warrants special comment. In overall terms, when the stocking rate was doubled from 3.7 (district average at the time this study was initiated) to 7.4 ewes/ha there was no significant effect on the proportion of barren ewes. However, at 12.4 ewes/ha this proportion rose from 29 to 36%, lamb mortality increased and the proportion of lambs weaned fell from 58 to 49%. Of added significance, the subsequent incidence of mortality among weaners over the following summer also increased dramatically (from about 10 to 20%) with the net result that some 20% fewer hoggets were produced. Although overall productivity, when expressed in terms of lambs weaned per hectare, increased with increasing stocking rate, the reduction in biological efficiency per breeding ewe would also require careful consideration before advocating stocking rates greater than 8 sheep/ha. Stocking rate is the most important variable affecting productivity per hectare, but on-farm decisions will be moderated by farmer attitudes to increased risk and reduced production per head.

The relation between time of lambing and fertility in this study also requires discussion. First, the results clearly show no difference in reproductive performance between autumn and spring lambings when measured either as the proportion of ewes lambing or the proportion of ewes twinning. This finding is in conflict with most of the published work from eastern Australia (see the review in Part 1), but is generally in accordance with subsequent studies with Merinos in Western Australia. The present results demonstrate that liveweight decreases through the summer and autumn months such that ewes joined in March for a spring lambing (mean weight 43 kg) were on average 8 kg lighter

than those joined for autumn lambing (mean weight 51 kg) in November. There is no doubt that liveweight at joining is related to both ovulation and twinning rates and it seems that the potential advantage to be gained by joining later in the breeding season may be partially or completely offset by the general decline in liveweights that is a characteristic of unsupplemented sheep in a Mediterranean environment. Should economically practical means of maintaining, or even increasing, liveweight in the autumn months become possible there may be a profitable increase in number of lambs weaned.

While there was no difference between the autumn and spring lambings, the overall level of flock fertility was significantly depressed for ewes lambing in winter. Compared with lambing either earlier or later, the incidence of barren ewes in the winter lambing treatments rose from 28 to 38%. This (unexpected) depression in fertility may have been associated with the effects of higher summer temperatures during joining on ram and/or ewe fertility. Lindsay *et al.* (1975) noted that reduced conception in flocks was negatively correlated with the maximum temperature during joining. Futher indication of depressed fertility with winter lambings was also observed in more recent times in a large time of joining experiment with Merino ewes at Beverley (R. J. Suiter, unpublished data).

The problems of winter lambing were not restricted to a reduction in ewe conception. In the present study, winter lambing was also associated with a higher level of lamb mortality (autumn—19%, winter—27%, spring—17%) and so the cumulative effect of lambing in winter on the proportion of lambs weaned was considerable (autumn—60%, winter—47%, spring—59%).

In designing a flock management system one must consider the effects of both lambing time and stocking rate on flock fertility. In general terms, at the same stocking rate, the percentage of lambs weaned from the autumn or spring lambing ewes were similar. In the case of winter lambing, however, the combined effects of lower flock fertility associated with lambing at this time and the effects of the highest stocking rate on flock fertility considerably reduced overall productivity, particularly the proportion of lambs weaned per ewe joined. For example in the present study the overall percentage of lambs weaned for winter lambing ewes run at 12.4 ewes/ha over four years was only 39%. It is significant to note that many sheep producers, when faced with the dilemma of choosing between an autumn (with supplementary feed for breeding ewes) or spring lambing (with lighter weaners in December and the possible need for supplementary feeding of weaners through the summer) opt for the compromise—a winter lambing. The evidence presented here suggests that, especially at high stocking rates, the winter lambing compromise may lead to lower sheep production than with either autumn or spring lambing.

Lamb growth to weaning

With autumn lambing there was a marked effect of stocking rate on the rate of lamb growth to weaning. The higher the stocking rate the lower the rate of liveweight gain. With winter lambing there was no difference in liveweight gain of lambs between the 3.7 and 7.4 ewes/ha treatments, but in difficult years lambs at 12.4 ewes/ha grew more slowly. In contrast, there was virtually no effect of stocking rate on lamb growth with August lambing and this system at 12.4 ewes/ha produced the highest weight of lamb weaned per hectare.

The practical implications of these results warrant consideration. The present study involved no supplementary feeding for autumn lambing ewes and it is significant that supplementary feeding may have reduced the depressing effects of increased stocking rate on growth in autumn born lambs. If the spring lambing option is chosen it is important to note that the weaning weight of "spring" dropped lambs was reduced if they were born after September 1. This presents some difficulty in planning an "ideal" spring lambing management system. Lambing in winter before August should be avoided due to the possibility of reduced lambing and weaning percentages; lambing after September 1 is likely to lead to reduced weaner growth. Obviously a compromise is necessary as a lambing period of one month (August) is too short to maximise ewe conception.

In this study, spring lambing started on or about August 15, but it is the author's current opinion that for the Kojonup area lambing from the last week of July would be a better system. For areas with a longer growing season, lambing could be further delayed.

Weaner losses

Lambs weaned from the experiment were always grazed as one flock at a low stocking rate and fed a cereal grain supplement throughout the summer. Nearly all weaner deaths occurred during December, January and February and were usually associated with low weaning weights. The losses were therefore significantly higher among the weaners from the 12.4 ewes/ha group than in the two lighter stocking rate groups. This effect of stocking rate applied particularly to weaners from the autumn and winter lambing groups. The implications for management emphasized the need to feed weaners according to weight and condition. Regardless of date of birth or previous stocking rate treatment, small light-weight weaners will require preferential supplementation with highly digestible feed to avoid excessive losses from December through to the opening seasonal rains.

Liveweight gain in pregnant ewes

In nearly all years, the non supplemented autumn-lambing ewes gained less than 4.5 kg in late pregnancy. This is generally considered to be an unsatisfactory level of liveweight gain for multiparous ewes, although the author's experience with the generally mild weather conditions experienced in most autumns in south-western Australia suggests that the recommendations for liveweight gain in uniparous ewes through late pregnancy may well need re-assessment.

Weight gain through late pregnancy with winter lambing was generally satisfactory except at 12.4 ewes/ha in those years with a late break to the season. In such years not only is the advent of green feed delayed, but early pasture growth is reduced due to low winter temperatures. Farmers practising winter lambing at stocking rates greater than 8 sheep/ha will need to maintain a strategic reserve of conserved pasture or grain for supplementary feeding in years with late or "false" breaks.

In all years, regardless of stocking rate, weight gains for spring lambing ewes in late pregnancy were adequate. Where supplementary feed is not offered, the nutritional requirements of ewes in late pregnancy are best provided by a spring lambing system. There is rarely a need for farmers to reserve feed for lambing ewes if spring lambing is practised. More significantly, by altering lambing time to spring (August), higher stocking rates may be carried without the need to feed lambing ewes.

Growth rates after weaning

These results describe the effects of time of lambing on growth by comparing the liveweights at a common age (not at a common date). Thus, the mean weight of the autumn-born sheep at 15 months of age (i.e. in July) was lower than that for either winter or spring-born sheep (in September and November respectively). In part, this effect was due to the consistently lighter weight of autumn-born sheep from non-supplemented ewes grazed at 12.4 ewes/ha, but it is also influenced by the different growth patterns of sheep born in different months.

Although autumn-born sheep at 15 months of age (in July) are lighter than winter or spring-born sheep at 15 months (in September and November respectively), the latter groups are reaching or have reached their peak in growth as pastures dry off. In contrast, if the treatments are compared at 20 months of age (autumn-born in December, winter-born in February and spring-born in April) a different picture will emerge. The autumn-born sheep will have reached peak liveweight for the season whereas the spring-born sheep will have lost weight through summer and autumn. These trends and the effects of time of birth on adult production are clearly illustrated from a more recent experiment with Merino sheep at Mt Barker (Marshall 1985).

Farm budgets today are sensitive to the sale prices for young stock, particularly with the export trade for live sheep. It is therefore important to realise that on any day through the summer-autumn months, sheep born in autumn (provided they have come from reasonably nourished supplemented ewes) will normally be heavier than those born in either winter or spring, though the deficit in the later born animals can be overcome with feeding (Marshall 1985).

Wool production of ewes

As was to be expected, increasing stocking rate significantly reduced greasy wool production per head. Nevertheless, the results clearly demonstrate the dramatic increase in wool production per hectare to be obtained as a result of increasing stocking

rate. No difference was found between autumn and winter lambing ewes grazed at the same stocking rate in any year. The highest wool production per hectare was achieved with spring lambing at 12.4 ewes/ha—58.1 kg of greasy wool/ha which at 1985 prices would give a gross return of at least $200 per hectare.

The effect of increasing stocking rate on the proportion of tender fleeces was affected by time of lambing. In autumn there was a relatively high proportion of tender fleeces (14-24%) at all stocking rates. In winter it was only at 12.4 ewes/ha that this occurred (14%) whereas with spring lambing the proportion of tender fleeces was negligible. These results are of considerable practical significance in view of the impending introduction of sale by additional measurement (SAM) including strength and length measurements and their possible impact on prices for objectively measured tender wool.

Pastures and stocking rates

Stocking rate was the major variable affecting pasture composition. Increasing stocking rate reduced the proportion of grass from 84% at the lower stocking rate to 34% in the highest. This was accompanied by an increase in the proportion of erodium and capeweed. Surprisingly, the proportion of subterranean clover in the pasture remained constant at all stocking rates. Although the results show that autumn lambing slightly reduced pasture on offer, the major factor affecting pasture on offer in the early part of the growing season was stocking rate.

The findings have clearly shown that subterranean clover based pastures in the Great Southern statistical areas were generally capable of carrying much higher stocking rates per hectare than had been assumed in the 1960s. The results suggest that, for the Kojonup area, stocking rates of 7-9 ewes/ha can be carried without harmful effects on production per head and, provided that spring lambing is practised, without recourse to supplementary feeding. Even higher stocking rates can be carried, but this will lead to a reduction in flock fertility and a possible increase in weaner/hogget mortality. Nevertheless, despite such effects, the highest levels of production per hectare in terms of both wool and lambs weaned occurred with spring lambing ewes grazed at 12.4/ha.

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References

Agricultural Research Council (1980). The nutrient requirements of ruminant livestock. A technical review by an A.R.C. Working Party (Commonwealth Agricultural Bureau, Farnham Royal, Great Britain).

Alexander, G. (1962). Temperature regulation in the new-born lamb. IV. The effect of wind and evaporation of water from the coat on metabolic rate and body temperature. *Australian Journal of Agricultural Research* **13** : 82.

Alexander, G., McCance, I., and Watson, R. H. (1955). Some observations on losses among Merino lambs. *Australian Veterinary Journal* **31** : 85.

Alexander, G., Peterson, J. E., and Watson, R. H. (1959). Neo-natal mortality in lambs: Intensive observations during lambing in a Corriedale flock with a history of high lamb mortality. *Australian Veterinary Journal* **35** : 433.

Allden, W. G. (1956). Time of mating studies. Part 2. *Journal of Agriculture, South Australia* **59** : 410-417.

Allden, W. G. (1968a). Undernutrition of the Merino sheep and its sequelae. I. The growth and development of lambs following prolonged periods of nutritional stress. *Australian Journal of Agricultural Research* **19** : 621.

Allden, W. G. (1968b). Undernutrition of the Merino sheep and its sequelae. II. The influence of finite periods of arrested growth on the subsequent wool growth, fleece development, and utilization of feed for wool production of lambs. *Australian Journal of Agricultural Research* **19** : 639.

Allden, W. G. (1968c). Undernutrition of the Merino sheep and its sequelae. III. The effect of lifetime productivity of growth restrictions imposed at two stages of early post-natal life in a Mediterranean environment. *Australian Journal of Agricultural Research* **19** : 981.

Arnold, G. W., McManus, W. R., and Bush, I. G. (1964). Studies in the wool production of grazing sheep. I. Seasonal variation in feed intake, liveweight and wool production. *Australian Journal of Experimental Agriculture and Animal Husbandry* **4** : 392.

Bennett, D., Morley, F. H. W., Clark, K. W. and Dudzinski, M. L. (1970). The effect of grazing cattle and sheep together. *Australian Journal of Experimental Agriculture and Animal Husbandry* **10**: 694.

Bennetts, H. W. (1958). Unthriftiness of weaner sheep in Western Australia. *Australian Veterinary Journal* **34** : 398.

Black, J. N. (1955). The interaction of light and temperature in determining the growth rate of subterranean clover (*Trifolium subterraneum* L.). *Australian Journal of Biological Sciences* **5** : 330.

Coop, I. E. (1950). The effect of level of nutrition during pregnancy and during lactation on lamb and wool production of grazing sheep. *Journal of Agricultural Science (Cambridge)* **40** : 311.

Coop, I. E., and Hayman, B. I. (1962). Liveweight-productivity relationships in sheep. II. Effect of liveweight on production and efficiency of production on lamb and wool. *New Zealand Journal of Agricultural Research* **5** : 265.

Davies, H. Lloyd. (1962). Studies on time of lambing in relation to stocking rate in south-western Australia. *Proceedings of the Australian Society of Animal Production* **IV** : 113.

Davies, H. Lloyd. (1964). Lamb losses in south-western Australia. *Proceedings of the Australian Society of Animal Production* **V** : 107.

Davies, H. Lloyd. (1965). Studies in sheep nutrition and reproduction. Ph.D. Thesis, University of Western Australia.

Davies, H. Lloyd (1968). Studies in pasture management for the breeding ewes. 1. The effects on ewe liveweights, incidence of pregnancy toxaemia, lamb birth weights, and neo-natal mortality. *Australian Journal of Agricultural Research* **19** : 605.

Davies, H. Lloyd and Greenwood, E.A.N. (1972). Liveweight and wool growth of sheep in response to the quantity and botanical composition of annual pasture induced by nitrogen fertilizer and stocking treatments. *Australian Journal of Agricultural Research* **23** : 1101.

Davies, H. Lloyd and Humphries, A. W. (1965). Stocking rate and wool production at Kojonup. I. Wether sheep. *Journal of Agriculture, Western Australia* (4th Series) **6** : 409.

Davies, H. Lloyd and Maller, R. A. (1970). the fertility of ewes grazing pastures containing different proportions of subterranean clover in south-western Australia. *Proceedings of the Australian Society of Animal Production* **VIII** : 394.

Davies, H. Lloyd and Nairn, M. (1964). Correlations between lambing performance and incidence of cystic endometrium in ewes. *Proceedings of the Australian Society of Animal Production* **V** : 62.

Davies, H. Lloyd; Rossiter, R. C. and Maller, R. (1970). The effects of different cultivars of subterranean clover (*T. subterraneum* L.) on sheep reproduction in the south-west of Western Australia. *Australian Journal of Agricultural Research* **21** : 359

Dawe, S. T. (1968). A comparison of the wether progeny of Border Leicester, Cheviot and Merino rams mated to Merino ewes. *Proceedings of the Australian Society of Animal Production* **VII** : 204.

Dennis, S. M. (1974). Perinatal mortality in Western Australia. 1. General Procedures and Results. *Australian Veterinary Journal* **50** : 443.

Donald, C. M. (1951). Competition in pasture plants. 1. Intra-specific competition among annual pasture plants. *Australian Journal of Agricultural Research* **2** : 355.

Doney, J. M. and Smith, W. F. (1961). The fleece of the Scottish Blackface sheep. I. Seasonal changes in wool production. *Journal of Agricultural Science (Cambridge)* **56** : 360.

Drake, F. and Elliott, N. M. (1960). The production of wool per acre. *Journal of Agriculture, Victoria* **58** : 645.

Dun, R. B. (1961). Breeding Merino sheep for higher lamb production. *Wool Technology and Sheep Breeding* **8** : 9.

Dun, R. B., Ahmed, W., and Morrant, A. J. (1960). Annual reproductive rhythm in Merino sheep related to the choice of a mating time at Trangie, central western New South Wales. *Australian Journal of Agricultural Research* **11** : 805.

Fels, H. E., Neil, H. G., Ralph, I. G. and Suiter, R. J. (1969). The effect of season on the ovulation rates of Merino and crossbred ewes in Western Australia. *Australian Journal of Experimental Agriculture and Animal Husbandry* **9** : 267

Fogarty, N. M. (1972). Crossbreeding for lamb production. I. Survival and growth of first cross lambs. *Australian Journal of Experimental Agriculture and Animal Husbandry* **12** : 234.

Greenwood, E. A. N., Davies, H. Lloyd and Watson, E. R. (1967). Growth of an annual pasture on virgin land in south-western Australia including effects of stocking rate and nitrogen fertilizer. *Australian Journal of Agricultural Research* **18** : 447.

Hunter, G. L. (1959). A contribution to the study of the problem of low fertility among Merino ewes in South Africa. *Journal of Agricultural Science (Cambridge)* **52** : 283.

Johnston, D. A. W. (1983) ed. Wheat in Western Australia, Western Australian Department of Agriculture, Bulletin No. 4076.

Jones, J. M., Dumenon, W. H., Davies, S. P., Warwick, B. L. and Patterson, R. E. (1944). Influence of age, type and fertility in Ramboullet ewes on fineness

of fibre, fleece weight, staple lengths and body weight. Bulletin of Texas Agricultural Experiment Station No. 657.

Jones, M. B. and Evans, R. A. (1960). Botanical composition changes in annual grassland as affected by fertilization and grazing. *Agronomy Journal* **52** : 459.

Kelley, R. B. (1939). Female aspects of relative fertility in sheep. *Australian Veterinary Journal* **15** : 184.

Kelley, R. B., and Shaw, H. E. B. (1943). Fertility in sheep. CSIR Bulletin No. 166.

Langlands, J. P. and Bennett, I. L. (1973). Stocking intensity and pastoral production. III. Wool production, fleece characteristics and the utilisation of nutrients for maintenance and wool growth of Merino sheep grazed at different stocking rates. *Journal of Agricultural Science, (Cambridge)* **81** : 211.

Lightfoot, R. J. (1967). The effects of shearing time and stocking rate on wool production. *Journal of Agriculture, Western Australia* (4th Series), **8** : 90.

Lindsay, D. R., Knight, T. W., Smith, J. F. and Oldham, C. M. (1975). Studies in ovine infertility in agricultural regions of Western Australia : Ovulation rate, fertility and lambing performance. *Australian Journal of Agricultural Research* **26** : 189.

Marshall, T. (1985). Effect of month of birth and first summer's nutrition and the productivity of Merino wethers. *Australian Journal of Experimental Agriculture* **25** : 25: 777-782.

McGarry, W. L. and Stott, I. (1961)—Time of lambing experiment. *Journal of Agriculture, Western Australia* (4th Series), **2** : 279.

McMeekan, C. P. (1956). Grazing management and animal production. *Proceedings of the International Grasslands Congress* **7** : 146.

Moore, R. M., Barrie, Nancy and Kipps, E. H. (1946). Grazing management : Continuous and rotational grazing by Merino sheep. CSIR Bulletin No. 201.

Morley, F. H. W. (1948). Some seasonal factors affecting fertility among Merino ewes in the Trangie District, New South Wales. *Australian Veterinary Journal* **24** : 106.

Moule, G. R. (1954). Observations on mortality amongst lambs in Queensland. *Australian Veterinary Journal* **30** : 153.

Oldham, C. M. (1978). The breeding season in the Merino—The use and abuse of teaser rams. *Proceedings of Seminar on Sheep Fertility* **2** Narrogin : 5.

Owen, J. B. (1957). A study of the lactation and growth of hill sheep in their native environment and under lowland conditions. *Journal of Agricultural Science, (Cambridge)* **48** : 387.

Peterson, R. G., Lucas, H. L. and Mott, G. O. (1965). Relationship between rate of stocking and per animal and per acre performance on pasture. *Agronomy Journal* **57** : 27.

Radford, H. M. (1959). Variation in the incidence of twin ovulation in Merino ewes on a constant plane of nutrition. *Australian Journal of Agricultural Research* **10** : 377.

Radford, H. M., Watson, R. H. and Wood, G. F. (1960). A crayon and associated harness for the detection of mating under field conditions. *Australian Veterinary Journal* **36** : 57.

Reeve, J. L. and Sharkey, M. J. (1980). Effect of stocking rate, time of lambing and inclusion of lucerne on prime lamb production in north-east Victoria. *Australian Journal of Experimental Agriculture and Animal Husbandry,* **20** : 637.

Rossiter, R. C. (1961). The influence of defoliation on the components of seed yield in swards of subterranean clover *(Trifolium subterraneum). Australian Journal of Agricultural Research* **12** : 821.

Rossiter, R. C. (1964). The effect of phosphate supply on the growth and botanical composition of annual type pasture. *Australian Journal of Agricultural Research* **15** : 61.

Rossiter, R. C. (1966). Ecology of the Mediterranean annual type pasture. *Advances in Agronomy*—**18** : 1.

Schinckel, P. G. (1954)—The effect of the ram upon the incidence and occurrence of oestrus in ewes. *Australian Veterinary Journal* **30** : 187.

Schinckel, P. G. (1955). Inheritance of birthcoats in a strain of Merino sheep. *Australian Journal of Agricultural Research* **6** : 595.

Sidwell, G. M., Everson, D. O. and Terrill, C. E. (1964). Lamb weights in some pure breeds and crosses. *Journal of Animal Science* **23** : 105.

Sinclair, A. N. (1950). A note on the effect of the presence of rams on the incidence of oestrus in maiden Merino ewes during spring mating. *Australian Veterinary Journal* **26** : 37.

Stevenson, P. D. (1968). Time of birth and growth to 18 months in fine wool Merino ewes. *Proceedings of the Australian Society of Animal Production,* **7** : 212.

Story, L. D. and Ross, D. A. (1960). Effect of shearing time on wool. VI. The rate of growth of wool and its relation to time of shearing. *New Zealand Journal of Agricultural Research* **3** : 113.

Thompson, D. W., and Schinckel, P. G. (1952). Incidence of oestrus in ewes. *Empire Journal of Experimental Agriculture* **20** : 77.

Thomson, W. and Aitken, F. C. (1959). Diet in relation to reproduction and the viability of the young. Pt. II. Sheep : world survey of reproduction and review of feeding experiments. Commonwealth Bureau of Animal Nutrition Technical Communication No. 20.

Underwood, E. J., Shire, F. L., and Davenport, N. (1944). Studies in sheep husbandry in W.A., V—The breeding season of Merinos, Crossbred and British breed ewes in the Agricultural districts. *Journal of Agriculture, Western Australia* (2nd Series), **21** : 135.

Wallace, L. R. (1948). The growth of lambs before and after birth in relation to the level of nutrition. *Journal of Agricultural Science (Cambridge)* **38** : 93.

Watson, R. H. (1953). Studies on seasonal variation in the level of fertility in Merino ewes. I. Observations on mating, pregnancy and lambing at intervals of four months. *Australian Journal of Agricultural Research* **4** : 349.

Watson, R. H. and Elder, E. Marigold (1961). Neo-natal mortality in lambs : Further observations in a Corriedale flock with a history of high lamb mortality. *Australian Veterinary Journal* **37** : 283.

Watson, R. H. and Radford, H. M. (1966). Seasonal variation in fertility in Merino ewes : the reproductive wastage associated with mating in winter, spring, summer or autumn. *Australian Journal of Agricultural Research* **17** : 335.

Wroth, R. H. and Lightfoot, R. J. (1976). A study of reproductive wastage among commercial sheep flocks grazing oestrogenic pastures in south-western Australia. *Proceedings of the Australian Society of Animal Production* **11** : 225.

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