A Study of Out-of-Season Lamb Production in the Lower North Island of New Zealand

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STEPHEN TODD MORRIS

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ABSTRACT

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The objective of this study was to evaluate out-of-season lamb production in the lower North Island of New Zealand. Ewes representing three crosses (Border Leicester x Romney (BR), Poll Dorset x BR (PBR) and Suffolk x BR (SBR)) and three birth years were reared, under commercial farming conditions, to enter an out-of-season lambing experiment. Suffolk x BR hoggets had significantly ($P<0.01$) heavier 16 month liveweights than PBR or BR hoggets. There were inconsistent differences in liveweight between PBR and BR ewe hoggets. Border Leicester x Romney hoggets produced more ($P<0.01$) greasy wool at the yearling shearing than PBR or SBR hoggets.

The same sheep were then assigned to one of two lambing policies (June or August) at their 2-year-old mating and remained within that policy while they were evaluated for their 2-year-old (1987, 1988, 1989) and 3-year-old (1988, 1989, 1990) lambing performance. Lambing policy did not influence the proportion of mated ewes that lambed but there were more ($P<0.05$) multiple births in the August-lambing ewes. Birth weights and weaning weights of the June-born lambs were significantly ($P<0.001$) lower than those of their August-born counterparts. June-lambing ewes produced more ($P<0.001$) wool (on average by 0.5 kg) than August-lambing ewes. Border Leicester x Romney ewes produced more ($P<0.001$) greasy wool per year (by 0.7 to 1.2 kg) than PBR ewes while PBR ewes outperformed SBR ewes (by 0.3 to 0.5 kg) for annual greasy wool production. Reproductive differences between the ewe crosses were small and non-significant, although PBR ewes reared the heaviest lambs.

In an attempt to determine when the extra wool growth occurred in June-lambing compared to August-lambing ewes, six-weekly midside patch wool growth measurements were taken throughout a 12-month period on a sample of the same three ewe crosses described earlier. It was found that the seasonal decline in wool growth rate that normally occurs over the winter months in August-lambing ewes was minimised in June-lambing ewes. Associated with this effect was a significant ($P<0.05$) increase in mean fibre diameter and an increase in staple strength at the following October shearing in June-lambing ewes.

The next experiment was designed to determine the relationships between sward surface height, intake and production for lactating June-lambing ewes. The organic matter intake (OMI) of June-lambing ewes was not influenced by a range (2.6 - 7.8 cm) of sward surface heights (SSH) during week 3 of lactation. Between weeks 4 and 7 of lactation, ewe OMI increased up to a SSH of 7.8 cm while in week 8 of lactation there was no increase in OMI between ewes grazing 4.4 or 7.8 cm swards. Sward surface height had no effect on ewe midside wool growth, mean fibre diameter or lamb growth but ewes on the 2.6 cm sward lost 8-10 kg more liveweight during lactation than those on the 4.4 and 7.8 cm swards. These results suggest that June-lambing ewes in good condition can maintain lamb growth at low (2-3 cm) SSH but at the expense of ewe liveweight loss.

The final trial investigated the effect of SSH on ewe intake and performance during the last month of pregnancy in June- and August-lambing ewes. Ewe OMI, condition score and liveweight gain increased as SSH increased from 2.0 to 8.0 cm. There was no effect of SSH on ewe midside wool growth, mean fibre diameter or lamb birth weights. June-born lambs were significantly ($P<0.05$) lighter at birth than August-born lambs across all SSH treatments. At the same SSH, June-lambing pregnant ewes achieved similar OMI to those of August-lambing ewes.

The results of these studies are discussed in the context of the development of out-of-season lambing systems for the lower North Island of New Zealand.

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This work is dedicated to the memory of my late mother, who posed the questions in my formative years and would have loved to have read this thesis.

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LIST OF ABBREVIATIONS

BR	Border Leicester x Romney
CIDR	Controlled Internal Drug Releasing device
CRC	Controlled Release Capsule
CFW	Clean Fleece Weight
cm	centimetre(s)
d	day(s)
°C	degrees celcius
°S	degrees latitude South
DM	Dry Matter
DMI	Dry Matter Intake
DOMI	Digestible Organic Matter Intake
epg	eggs per gram
EPM	Ellinbank Pasture Meter
FO	Faecal Output
g	grams(s)
gf	grams of fibre
GFW	Greasy Fleece Weight
ha	hectare(s)
HFRO	Hill Farming Research Organisation
iu	international unit(s)
kg	kilogram(s)
K	efficiency of utilisation of metabolisable energy
M	Maintenance
MAF	Ministry of Agriculture & Fisheries
ME	Metabolisable Energy
MFD	Mean Fibre Diameter
MJME	Megajoules of Metabolisable Energy
ml	millilitre(s)

mg	milligram(s)
μg	microgram(s)
m	metre(s)
μm	micrometre(s)
N/Ktex	Newtons per Kilotex
OF	Oesophageal Fistulated
OM	Organic Matter
OMI	Organic Matter Intake
OMD	Organic Matter Digestibility
PBR	Poll Dorset x (Border Leicester x Romney)
PMSG	Pregnant Mare Serum Gonadotrophin
RH	Relative Humidity
s	second(s)
SBR	Suffolk x (Border Leicester x Romney)
SSH	sward surface height(s)
v.	versus
WRONZ	Wool Research Organisation of New Zealand
X	tristimulus value (red)
yr	year(s)
Y	tristimulus value (green)
Z	tristimulus value (blue)

Statistical terms

SEM	Standard Error of the Mean
NS	P > 0.10
†	P < 0.10
*	P < 0.05
**	P < 0.01
***	P < 0.001
r	correlation

CHAPTER I

INTRODUCTION

BACKGROUND

Sheep farming in New Zealand is normally a seasonal activity in which the lambing date is traditionally determined by the pattern of pasture production. Ewes are usually mated in the autumn (March-May) so that they lamb at the onset of the spring flush of pasture growth. The seasonal nature of the grassland cycle dictates that most pasture-fed lambs reach slaughter age during the 6-month period December to May. In the 1990/91 season, for example, 80% of all lambs were slaughtered during the months of December to March inclusive (NZMPB 1992). This represents a highly seasonal slaughter pattern and creates marketing difficulties. Furthermore the economic efficiency of processing is seriously affected by this seasonality of production because plant built to cope with a seasonal peak is underutilised for much of the year. The increased consumption of pork and poultry meat at the expense of sheep meat over the last 15 years (Johnson 1989) can be partly attributed to the year-round supply of these meats. If New Zealand sheep meat is to compete more effectively in international markets, sheep production systems should aim for a more even year-round production and supply to achieve a greater efficiency in the processing (and hence a reduction in production costs) and marketing of sheep meat.

Numerous researchers have highlighted the need to extend the New Zealand lamb killing season. Nordmeyer (1974) recommended that the Ministry of Agriculture and Fisheries (MAF) work with farmer organisations and investigate factors that limit the spread of the lamb kill. Taylor (1982) highlighted the relatively short length of the New Zealand lamb killing season in comparison with that of its competitors and the minimal research into how farming methods might be changed to increase the spread of lamb production. He further stated that the conflict of seasonal production with the capital requirements of a modern technological processing industry had become increasingly apparent as New Zealand diversified its markets. Furthermore, the National Research Advisory

Council's Science and Technology review (1984) found that the length of the killing season had a dominant effect on processing charges and maintained that animal production studies to spread the killing season were essential.

Gould (1987) suggested that the supermarket demand for a 12-month supply of chilled lamb will force meat companies into working directly with farmers to devise ways in which lambs can be grown to meet an extended slaughter season. Extension of the lamb killing season should improve farmer returns and increase the opportunities available to lamb growers to adopt alternative sheep production systems. Some of these opportunities will now be discussed in more detail.

Market Requirements

Some observers believe that the markets for commodity frozen meat products are declining in profitability to the point of being non-viable (Gould 1987). New Zealand's customers have become increasingly disenchanted with frozen lamb, but will pay a premium for fresh or chilled lamb (Johnson 1989). In many markets lamb is regarded as a luxury meat and the number of potentially wealthy customers is increasing as incomes rise in most western and south east Asian countries. By the year 2000, lamb is likely to be regarded as a luxury meat in all countries other than New Zealand and Australia. Associated with the tag of luxury will be the connotation of quality, most likely in a fresh or chilled form, and with a distinctly well recognised brand name. Self-service supermarkets have replaced the traditional butcher as the major retail meat outlet in most of the high-priced markets of the world. These supermarkets demand an attractively presented and packaged product. The development of improved systems of packaging, which extends the shelf storage life of chilled meat by up to 16 weeks, has made sea freighting of chilled lamb to the Northern Hemisphere supermarket trade a commercial reality (Chrystall *et al*. 1989). However, the development of the chilled lamb trade has been slow and only 3% of lamb exported in 1990/91 was in a chilled form with the balance being in the form of frozen carcasses or cuts (Table 1.1). Future projections, however, are that by the year 2000 the proportion of lamb exported in chilled state could account for up to 60% of the total lamb exports (Gould 1987).

Table 1.1 **Export tonnage of lamb and the proportion exported in frozen or chilled state.**

	1983[1]	1987[1]	1991[1]	2000[2]
Export (tonnes)	445,118	349,014	286,081	600,000
Frozen carcasses (%)	82	66	43	-
Frozen cuts (%)	17	33	54	-
Total Frozen (%)	99	99	97	40
Chilled (tonnes)	1,105	3,265	9,418	360,000
Chilled (%)	0.2	0.9	3.3	60.0

1 New Zealand Meat Producers Board Annual Reports.
2 Gould (1987).

The steady but slow increase in the chilled lamb trade has led to an increased market demand for a year-round supply of product. The greatest shortfall in supply has occurred in early to mid-spring and this has resulted in companies paying higher prices or premiums for lambs during this period. However, these premiums, whether they are designed to attract stock to keep expensive plants operating or to supply a year-round market, are seldom sufficiently consistent or large to cause farmers to consider permanent changes to their sheep management (Hawkins *et al.* 1989). The premiums probably have more to do with tactical competition for stock between different companies than with an attempt to substantially modify the seasonality of production. Traditionally these premiums exist at purchase whereas farmers require an early notice of premiums (prior to mating) if they are to move part of their flock to an out-of-season lambing policy. If predicted changes in tonnages of chilled lamb (Gould 1987) are to be realised, clearly targeted premiums for early lambs will need to be offered by the processing sector.

Regional Pasture Production and Climate Change

There are several distinct climatic regions in New Zealand and, as climate has the greatest single influence on patterns of pasture production (Rattray 1978a), it follows that regional variation in lamb production may be sensible. Lengthening the killing season to 12-month production may not be a profitable alternative in every region of New Zealand. In the Northern areas of New Zealand, autumn/winter lambing policies generate a transfer of feed demand from spring/summer to autumn/winter and may be a more appropriate strategy for matching feed supply and demand in these areas (Rumball 1980; Rumball & Boyd 1980). Likewise in the drier East Coast regions of New Zealand, where summer droughts are frequent and winters are mild, an early-winter lambing policy may be the best option to match feed demand with the seasonality of pasture production. Farmers from the Central Hawkes Bay region have been reported to regularly lamb ewes throughout May and June (Catley 1986). Out-of-season lambing in the southern parts of the South Island and in the colder hill country areas of the North Island might be considered as delayed lambing, ie situations where lambing is delayed until the October/November period. It therefore seems likely that the development of out-of-season lambing systems will follow distinct regional patterns with certain regions (eg Northland) being more suited to autumn lamb production systems and others (eg Southland) being best suited to a highly seasonal spring lamb production system .

Out-of-season lamb production systems will become more attractive to farmers if currently predicted scenarios regarding climate change become a reality. Recent studies have indicated that the atmospheric concentrations of carbon dioxide, and of certain trace gases such as methane and fluorocarbons, are increasing and are likely to cause a global warming and an associated climate change (Salinger 1987). Temperatures have risen 1°C over the past century and some climate models predict an eventual rise in surface temperature of between 1.5°C and 4.5°C by the year 2030 (Heerdegen 1990). Several researchers have attempted to predict the effects of these climate changes on pasture growth (Baars *et al*. 1990; Butler *et al*. 1990; Martin *et al*. 1991; Butler *et al*. 1992). In the short term, the possible effects of milder temperatures are longer growing seasons caused by higher winter pasture growth rates and an earlier onset of the peak spring pasture production. Large increases in autumn, winter and early-spring pasture production are likely and these would match the feed demand profile of autumn- and winter-lambing ewe flocks. Another likely climatic scenario is drier summers in the East Coast regions of New Zealand. One farmer response to this increased frequency of drought could be a shift to an autumn/winter lambing system, thereby allowing destocking through sale of lambs and cull ewes to occur before the onset of a summer drought.

Diversification

New Zealand sheep farmers often pursue diversification options on their farms to protect against fluctuating world market prices and adverse climatic conditions (McRae 1992). Out-of-season lamb production can be considered a form of diversification. A proportion of the ewe flock lambing in the autumn or winter would enable the farmer to take advantage of early season premiums for lambs and cull ewes (Lowe *et al.* 1988). An associated effect is a shift in, or a more equal division of, labour requirements. The early sale of cull ewes and their lambs would enable farmers to adopt other potentially more profitable farming enterprises throughout the late spring/early summer periods. These might include finishing cattle on flatter land or taking a cash crop with a short growing period (eg peas or barley). Each of these options could allow individual farmers to improve their cashflow and to diversify their farming operations to protect against market and climatic fluctuations.

The decline in sheep numbers that has occurred on New Zealand farms over the last 5 years (NZMWBES 1991) has coincided with an increased profitability in cattle. This change in relative profitability allows farmers to manage their sheep system in a manner which is secondary to the cattle enterprise. Thus the ewe flock could be considered opportunistic, in that ewes could be mated early, used for pasture control behind cattle in the autumn, sold after weaning in August and then another group of ewes purchased the following November/December. In this type of farming system, the more profitable cattle take precedence over sheep for all of the year except during ewe lactation in June/July. Destocking in early spring, through sale of cull ewes, enables high cattle growth rates, while control of pasture in late spring is achieved by the purchase of the new season's ewes.

Whatever the system or mix of systems chosen, out-of-season lamb production offers real possibilities for farmers to diversify and hence reduce their exposure to world market fluctuations and adverse local climatic conditions.

DEVELOPMENT OF OUT-OF-SEASON LAMBING SYSTEMS IN NEW ZEALAND

Issue to be Considered

The purpose of this section is to provide an overview of issues which must be considered when addressing the possible development of out-of-season lambing systems in New Zealand. These issues will be considered in more detail later in the chapter. Out-of-season lambing is defined as lambing outside the "normal period" for the region. Three major options have been identified for New Zealand conditions: autumn-lambing (April-May), winter-lambing (June-July) and late lambing (October-November). It is possible that most of the flock could lamb at one of these periods, but in many regions a more likely scenario is a split-lambing where ca. 30% of the flock lambs in winter (June) and the remainder at the normal time in the spring (August).

The choice of method for obtaining out-of-season lambs will depend on when a farmer wants the flock to lamb. Late lambing (October-November) is readily achieved given the normal patterns of sheep reproductive behaviour, but this is likely to be an option confined to "summer wet and winter cold" hill country conditions and for this reason will not be discussed further here. There are four ways of obtaining autumn- or winter-born lambs. They are: hormonal induction, use of teaser rams ("ram effect"), selection for early-mating flocks or a change to an early-mating breed of ewe. Each method has its own costs although the first three methods have the added advantage of retaining traditional breeds of ewe. The use of the ram effect is the cheapest method but is limited to advancing the breeding season by only 2-4 weeks while hormonal methods, although more costly, can be used to produce lambs throughout the year (see pages 10-14). The various methods are not mutually exclusive. For example, it may be necessary to stimulate earlier mating in a Poll Dorset x Romney flock by using the teaser ram effect. Selection for early-mating flocks offers the cheapest long-term option for obtaining out-of-season lambs. However, responses to selection, in terms of date of onset of oestrus and conception rates to an early mating, are likely to be slow where a spring-lambing flock is being converted to an autumn- or winter-lambing flock because of the low selection differentials which can be achieved in such selection programmes and because of the lack of any potential genetic marker in the ram for date of onset of the breeding season in the ewe.

Any change in breed or cross of ewe to obtain out-of-season lambs needs to be evaluated carefully with respect to its effect on total lamb and wool production, together with the extra production costs. A change in ewe breed or cross is likely to incorporate a ewe breed that has a longer breeding season but may also involve changing the terminal sire breed in order to produce lambs more suitable for the chilled Northern Hemisphere supermarket trade. The availability of new breeds and their crosses has to be ascertained before any farmer should contemplate changing the existing breed structure. When a mix of autumn/winter- and spring-lambing systems is planned within an existing flock, it would be preferable to use the existing spring-lambing ewe breed or cross to produce out-of-season lambs.

A change from spring-lambing to autumn- or winter-lambing systems will result in changes in the level, as well as the pattern, of lamb production. Lambing percentage, lamb mortality and lamb weaning weights are all likely to be affected by the change in lambing date (see pages 18-20). Changes might also be expected in ewe wool quantity and quality due either to a change in breed or cross or to an altered relationship between feed demand and supply for ewes in the earlier lambing policy. The high feed demand associated with the late pregnancy/lactation in autumn- or winter-lambing ewes occurs at a time when wool growth rate is at its slowest and the wool fibre at its thinnest and hence at a time when wool may be susceptible to breakage and an associated increase in tenderness (see pages 20-22).

Moving animal feed requirements away from the regular and pronounced seasonal pasture production curves would make lamb production very difficult in some regions of New Zealand. The May- or June-lambing ewe is lactating (a period of high feed requirements) during the winter months when pasture growth rates are declining (see pages 22-25). This contrasts with the spring-lambing ewe, which is lactating during the months of September and October when pasture growth rates are increasing. The introduction of an autumn- or winter-lambing policy is a major management task that requires careful planning, and significant adjustments may be needed to existing farming practices. With early lambing, problems such as low feeding levels (with its attendant metabolic problems) and poor ewe milk supply (leading to low lamb weaning weights) could substantially depress profitability.

Relationships between herbage allowance and production are not currently known for autumn- or winter-lambing ewes. Most researchers and farmers have assumed that the known feed requirements and herbage allowance/production relationships for spring-lambing ewes are appropriate for autumn- or winter-lambing ewes (see pages 22-25). These relationships need to be substantiated before any reliable modelling or feed budgeting of out-of-season lamb production systems can occur.

Historical Overview and Likely Systems

Techniques for obtaining out-of-season lambs in New Zealand were first reported by Welch & Tervit (1970). They found that artificially reducing day length, by placing sheep in darkened sheds from early December, would induce ewes to mate in January, as did treating ewes with progesterone sponges and an injection of pregnant mare serum gonadotrophin (PMSG). However, this technology was not adopted by farmers, primarily because meat companies never offered farmers sufficient incentives to produce early lambs and/or drug companies and veterinarians supplying the hormone preparations were not sufficiently aware of the application of the technology and did not take initiatives to organise farmers and processors to use the technology (Welch 1985).

New Zealand sheep production systems are based on matching feed demand with feed supply. This requires synchronisation of the increasing feed requirements of late pregnancy and lactation with the onset of the spring flush of pasture growth (Rattray 1978a). Lambing earlier in winter may result in late-winter and early-spring feed deficits. Improving the match of feed demand and supply relies mainly on manipulating the supply of feed by transferring, increasing the growth of, or purchasing, feed. In some regions of New Zealand, notably Northland (latitude 36° 42' S), pasture growth and hence feed supply is relatively evenly distributed among seasons (Baars 1976; Piggot *et al*. 1978). Winters are often mild and summers are extremely dry, making a transfer of feed demand through an autumn or winter lambing a more appropriate strategy of matching feed supply and demand (Rumball 1980; Rumball & Boyd 1980).

Two approaches to autumn and/or winter lambing have been used in Northland. The first involved the use of hormones (Andrewes & Taylor 1986), whereby a split lambing was induced in either autumn (April/May) for 30% of the flock, or winter (June/July) for 15% of the flock, with the remainder lambing at the normal time in the spring (August/September).

The second and more long term approach was to select ewes that mated naturally outside the normal breeding season. Andrewes (1983) reported that, with a flock of Poll Dorset ewes, a mid-April mean lambing date was successfully achieved by restricting joining periods and selecting ewes for an early mating date. Likewise McQueen (1986) and McQueen & Reid (1988) described a flock of Poll Dorset x Romney ewes in which the lambing date was advanced from September in 1977 to May/June in 1982 through natural mating procedures and selection for earlier mating. Bryant (1988) estimated that, during the 1987 season in Northland, 2500 ewes were lambed in late-April to mid-June and 7000 ewes were lambed in the mid-June to mid-July period.

Commercialisation of hormone treatments to achieve an autumn- or winter-lambing reached a peak in 1987 when 50,000 ewes were treated in the drier east coast regions of New Zealand (Quinlivan 1988). Subsequently interest has largely been confined to research flocks where aspects of ewe reproductive performance, lamb production and wool growth have been studied (Lowe *et al*. 1988; Reid *et al*. 1988; Smith *et al*. 1988a; Knight *et al*. 1989b; Morris 1989; Smith *et al*. 1989a).

Low cost systems utilizing Romney ewes and the ram effect have been the focus of MAF Technology research in Hawkes Bay (Muir 1990). Others have investigated the use of cull or cast-for-age ewes, previously spring-lambing, to obtain one out-of-season lambing before they are finally culled in August (Andrewes & Taylor 1986; Lowe *et al.* 1988). Premiums would then be available both for the early-born lambs and through the early sale of cull ewes after weaning in September.

The most common situation for farmers wishing to use out-of-season lambing will likely be to mate a proportion of the flock early. The proportion mated out-of-season will depend on many factors such as feed supply, premiums available and the feed requirements of other classes of stock on the farm. Major adjustments to stocking rates are likely and this is will affect the overall profitability of the whole farm system (Hawkins *et al.* 1989). The ability of markets to constantly and adequately reward those farmers willing to complicate farm management with out-of-season lambing is yet to be proven in New Zealand.

Techniques for Inducing Out-of-Season Breeding

The normal breeding season of ewes of the major breeds in New Zealand is from mid-March to mid-August (Smith *et al.* 1989b). There are differences in the time of onset and cessation of the breeding season between breeds (Kelly *et al.* 1976) and between locations for the same breed (Averill 1964; Quinlivan & Martin 1971; Kelly *et al.* 1976; Knight *et al.* 1983; Smith *et al.* 1987; Smith *et al.* 1989b). Usually there is a later onset and an earlier finish of activity with increasing degree of latitude and this is most likely related to differences in the ratio of light to dark. However, differences in the onset of oestrous activity have been measured in ewes at different locations but at the same latitude (Quinlivan & Martin 1971; Knight *et al.* 1989a).

The seasonal breeding pattern in New Zealand sheep breeds can place unacceptable restrictions on the adoption of out-of-season breeding. Furthermore, within the restricted breeding season there is a very short period (4-6 weeks) over which ovulation rates are at a maximum

(Montgomery *et al.* 1988). Therefore any attempt to advance or extend the breeding season tends to lead to an unacceptable reduction of 25-30% in the potential lambing percentage (Robinson 1990).

The Ram Effect

Towards the end of the non-breeding season, the introduction of rams to ewes will stimulate a proportion of the ewes to ovulate within 3-4 days (Schinckel 1954; Knight *et al.* 1978) although this ovulation is not accompanied by behavioural oestrus. The first oestrus plus ovulation occurs 18-24 days after ram introduction (Knight 1983). Using rams in this way it is possible to get a proportion of ewes mated 2-4 weeks earlier than the normal breeding season. The proportion of ewes ovulating and/or exhibiting oestrus after ram introduction is dependent on the breed of ewe and the time of year. Merino ewes have responded to the ram effect at almost any time during the anoestrous period (Lishman 1969) while Romney ewes respond only in late anoestrus (Edgar & Bilkey 1963). Large year to year variations are a feature of the ram effect, four weeks difference in the onset of oestrous activity having been recorded in the same ewes in successive years (Smith *et al.* 1988a). Climatic variables such as cloud cover or sunlight hours may contribute to this variation in the ram effect between years (Smith *et al.* 1989b).

A prerequisite for a response to the ram effect is that ewes are isolated from rams for a period prior to ram introduction. If ewes are run continuously with rams they can lapse into anoestrus similar to that in isolated ewes (Lishman 1969). Periods of isolation of between 17 and 34 days are equally effective (Oldham 1980). Recently there has been a suggestion that prior isolation of ewes from rams may not be necessary for the establishment of the ram effect, although it may affect the degree of synchrony in the ewes (Smith *et al.* 1989b).

A further source of variation in the ram effect arises from the choice of ram used. Poll Dorset rams have been reported to be superior to Romney rams in advancing the breeding season via the ram effect (Tervit *et al.* 1977; Meyer 1979). However, Knight *et al.* (1989b) have shown that Poll Dorset rams were no better than Romney rams at inducing the ram effect. The effect is due, at least in part, to a pheromone produced by the ram (Knight & Lynch 1980) and as such it is not surprising that individual rams (between and within breeds) differ in their ability to induce the effect. Enhancement of the ram effect can occur through brief contact between oestrous ewes and rams before the rams are introduced to anoestrous ewes (Knight 1985).

Induction of Breeding Using Hormones

The silent ovulation induced by the ram effect can be converted to an overt oestrus if ewes are administered progesterone for 12-14 days prior to ram introduction (Cognie *et al.* 1982). This technique will advance the breeding season by 5-6 weeks (Smith *et al.* 1989b). The effectiveness of the progesterone treatment depends on the time of year progesterone is administered to ewes, the breed of ewe used and the location of the treated ewes (Smith *et al.* 1991b). Progesterone was initially administered by injection (Dutt & Casida 1948) but, subsequent to this, intravaginal progesterone-impregnated sponges (Robinson 1965) have been the normal method of progesterone administration throughout the world. The CIDR (controlled internal drug releasing device; Alex Harvey Industries, New Zealand) is the most common method of progestagen administration used in New Zealand. The CIDR is usually inserted intravaginally into ewes for 12-14 days (McMillan 1987). Smith *et al.* (1989b) found that the onset of oestrus after CIDR use is earlier than after sponge treatment but that conception rates and rates of loss of the device (typically 1-2%) did not differ between the two methods of progestagen administration. Progestagen treatment alone must be accompanied by the introduction of rams at about the time of device removal, otherwise very few ewes will respond (Smith *et al.* 1987). The treatment does not result in oestrus or ovarian activity in ewes that are in deep anoestrus (eg September to December in New Zealand for Romney and Romney-derived breeds). However, this can be overcome by administration of pregnant mare serum gonadotrophin (PMSG). Details of seasonal changes in sensitivity to gonadotrophins are not readily available and dose levels are often chosen on the basis of intuition rather than scientific fact (Smith *et al.* 1989b). Smith *et al.* (1989b) found that 800 international units (iu) of PMSG (in combination with progestagen treatment) will ensure at least 90% of ewes mate at any time of the year, but suggested that 400 iu PMSG will suffice in most out-of-season breeding programmes. Response to PMSG is, however, dependent on breed (Quinlivan 1988) and although progestagen and PMSG treatment will induce oestrus and ovulation in the non-breeding season, those ewes that fail to conceive will quickly revert to anoestrus (Welch 1985). The incidence of this anoestrus depends on the time of treatment, breed of ewe used and their previous history of out-of-season breeding.

A decline in conception rate is a major disadvantage both in progestagen-treated and progestagen plus PMSG-treated ewes during the non-breeding season (Kelly *et al.* 1976; Smith *et al.* 1987; Knight *et al.* 1989b). These low conception rates can be improved by joining 10% of mature rams with the ewes rather than the normal 1-2% of rams (Gordon 1963; Bryant & Tomkins 1975). Welch (1985) suggested that rams should be joined with ewes progressively after CIDR removal. He achieved good conception rates by joining a small proportion (2% ram:ewe ratio) at CIDR withdrawal to obtain the ram stimulation effect. When approximately 50% of ewes had been mated (at about 36 hours post CIDR removal), as determined by raddle marks on the ewes, most of the rams were joined (6%); the remaining 2% were added 12 hours later. This type of management ensured rams did not exhaust sperm reserves on the first few ewes that come into oestrus and that most of the ewes were inseminated with high numbers of sperm.

Re-use of rams may also improve conception rates, possibly because rams in the non-breeding season have a store of poor quality sperm in the caudal epididymis. Therefore, staggering mating for hormonally-treated ewes not only reduces requirements for large numbers of rams but can also improve lambing performance (Knight *et al.* 1989b). A significant means of reducing the cost of hormone treatment to induce out-of-season breeding is to re-use CIDRs. Knight *et al.* (1989b) found that in ewes treated with used CIDRs (previously inserted for 12 days) there were 5.6% fewer ewes lambing and 9.3% fewer lambs born than in those treated with new CIDRs. At a cost of $ 4 per CIDR the extra lambs born in that trial from the use of new CIDRs cost $43 each. Therefore, it is economical to re-use CIDRs for at least a second out-of-season mating. Likewise CIDRs can be reused in the post-mating period in an attempt to improve embryo survival and hence pregnancy rate (McMillan 1987). However, the use of progesterone therapy post-mating to improve pregnancy rate and/or litter size has not always been successful (Kleemann *et al.* 1991; Smith *et al.* 1991a).

Social facilitation, or stimulation of ovarian and oestrous activity in anoestrous ewes by oestrous ewes, has been suggested as a relatively cheap method of advancing the breeding season (Welch 1985). Early research suggested that this resulted from a direct stimulation of the anoestrous ewes by the oestrous ewes (Oldham 1980). Knight (1985), however, has demonstrated that the effect of oestrous ewes in stimulating anoestrous ewes acts via the ram. The social facilitation effect is therefore integrated with the ram effect and may require only 1 or 2 hormonally-induced oestrous ewes per ram to sufficiently prime rams to achieve the effect.

Following the recognition of the pineal indoleamine, melatonin, as the chemical signal that transmits information on changing photoperiod, it has been shown that exogenously administered melatonin can advance the breeding season in highly seasonal sheep breeds (Wigzell *et al.* 1986; Williams *et al.* 1987; Wallace *et al.* 1988; Harris *et al.* 1989). However, the response to melatonin implants in Romney and Romney-derived (eg Coopworth) ewes has been inconsistent (Staples *et al.* 1986; Smith *et al.* 1989b) although Moore *et al.* (1988) did advance the breeding season in Romney ewes treated with melatonin in December for a mid-January mating. As with the other hormonal techniques used for inducing out-of-season breeding, the effectiveness of melatonin treatment depends upon the genotype and the depth of anoestrus of the ewes treated.

Selection of Breed

The eventual aim of farmers wishing to have ewes breed out-of-season should be to have a flock that will mate naturally over an extended period. This typically involves identification of breeds with long breeding seasons and the use of these animals in a breeding or crossbreeding programme to produce out-of-season lambs. Any breed chosen as a dam for early mating should excel in the following traits: number of lambs weaned per ewe lambing, lamb weaning weight, ewe carcass weight, fleece weight and ability to lamb year-round. Correct choice of terminal sire used for the out-of-season mating can also improve lamb growth rate and carcass quality. A further constraint is that the breed chosen for an out-of-season lambing programme should be readily accessible to farmers.

Breeding Season of New Zealand Sheep Breeds

The most numerous breed found in New Zealand, the Romney, commences oestrous activity in March and continues until August (McDonald 1971; Kelly *et al.* 1976; Smith *et al.* 1989a). There are differences, however, related to latitude and altitude (Averill 1964; Quinlivan & Martin 1971) and, even at the same latitude, there have been differences in the date of onset of oestrus activity within the Romney (Knight *et al.* 1990). Coopworth ewes have a longer breeding season than Romney ewes, starting earlier and finishing later (Smith *et al.* 1987; Smith *et al.* 1991b). There are isolated references in the literature to situations where oestrous activity commences much earlier than is normally found in Romney or Coopworth ewes. Catley (1986) and Muir *et al.* (1989) reported that Romney ewes in Hawkes Bay can commence cyclic activity in January while McMillan & Sealey (1989) found that Coopworth ewes in the Waikato region started cycling in December.

Poll Dorset ewes have been found to have extended breeding seasons in Canada (Dufour 1974), the United Kingdom (Hafez 1952) and Australia (Phillips *et al.* 1984; Hall *et al.* 1986). Likewise, the Australian Merino is generally acknowledged as having a prolonged breeding season that extends from December to October (Barrett *et al.* 1962; Knight *et al.* 1975; Oldham & Cognie 1980).

Under New Zealand conditions, however, Kelly *et al.* (1976) reported similar seasonal patterns of oestrous activity for the Poll Dorset, Merino and Romney breeds at Invermay (latitude 45°52'S). Knight *et al.* (1989a) showed that a proportion of Poll Dorset ewes located in the southern part of the North Island (Latitude 40° 39' S) continued to ovulate throughout the year. Poll Dorset ewes located in Northland have also been reported to ovulate throughout the year (Andrewes 1983; McQueen & Reid 1988). In summary, oestrous activity of New Zealand Merino and Poll Dorset ewes does not normally extend year-round, unlike that of their Australian counterparts, and breeding cannot therefore be guaranteed before January. This appears to be an environmental, rather than a genetic, effect as Australian Merinos transferred to New Zealand did not show any oestrous activity before January (Knight *et al.* 1990)

Because Poll Dorset and Merino ewes do not become completely anovular during their "non-breeding seasons" there is scope for selection or screening within these breeds and/or their crosses to develop a flock capable of year-round breeding. This has been done with Poll Dorset x Perendale (Andrewes & Taylor 1986) and Poll Dorset x Romney (McQueen & Reid 1988) flocks in Northland. The implication that date of onset of breeding season is under genetic control is substantiated by the heritability estimates of 0.24 reported for mean date of lambing in Southdown sheep in the United States of America (Thrift *et al.* 1971), 0.25 reported in a Canadian composite breed (Fahmy 1990) and 0.23 in a New Zealand Poll Dorset flock (Smith *et al.* 1992). Because some ewes may cycle throughout the year, progress in selection for an earlier lambing date may be due to either an earlier onset of oestrus activity in the season in which they lamb or a later finish to the previous breeding season. Rate of genetic gain is, however, limited because there is no easily identifiable physiological or endocrinological parameter in rams that might potentially be used as a predictor of genetic merit for date of onset of the breeding season in their female relative (Xu 1991).

Breeds Used for Out-of-Season Lambing

The Poll Dorset breed and its crosses have been the most common genotypes involved in out-of-season lamb production in New Zealand (Andrewes 1983; Bryant 1988; McQueen & Reid 1988; Smith *et al.* 1992). The Poll Dorset has a reputation for producing heavyweight lean carcasses (Kirton *et al.* 1974) and, when used as a dam breed, has high milk production and hence high pre-weaning lamb growth rates (Geenty & Jagusch 1974; Geenty 1979). However, the Poll Dorset breed suffers from a low wool production compared with the long-woolled breeds (eg Romney, Coopworth and Perendale) found in New Zealand (Bigham *et al.* 1978a; Clarke 1984). This lowered wool production is offset to some extent by an increased premium obtained for the finer and higher bulk wool clipped from Poll Dorset sheep (Hight & Dalton 1974; Knight 1984). In Northland, Poll Dorsets have been crossed with the Romney or Coopworth breeds in an attempt to improve the Poll Dorset's wool production in out-of-season lambing programmes. This has improved wool weights but to some extent at the expense of the straightbred Poll Dorset's longer breeding season.

Researchers in the central North Island have used the long-woolled breeds (eg Coopworth, Romney) in out-of-season lambing programmes with some success (Welch 1986; Knight *et al.* 1989a; Smith *et al.* 1989b). These dual purpose breeds have the advantage of high wool production and can equal the Poll Dorset for lamb production (Clarke 1984). In the drier east coast regions of New Zealand the Merino or Merino x longwool breeds (eg Corriedale and New Zealand halfbred) have been used successfully as dams of out-of-season lambs (Knight 1984; Quinlivan 1988). The Merino has the advantage of usually generating a higher price for its finer wool. There are some drawbacks to using the Merino, however, namely an increased incidence of footrot and flystrike, especially in the more humid North Island climate. Merino or Merino cross lambs have the disadvantage of inferior growth rates and poorer carcass quality than lambs generated by the Poll Dorset or the long woolled breeds (Knight 1984).

In summary, a wide range of breeds and crosses have been utilised for out-of-season lambing but there seems to be no conclusive evidence that one breed or cross is superior in all traits.

Effects of Out-of-Season Lambing on Lamb Production

A number of researchers have reported that mating ewes outside their normal breeding season results in fewer ewes lambing and a lower incidence of multiple births than occurs in comparable ewes lambing during the spring (Reid *et al.* 1988; Smith *et al.* 1988b; Smith *et al.* 1989b). McQueen (1986) found that, under Northland conditions, the number of lambs born per ewe lambing in autumn and spring was 115% v. 135% respectively. In a large field trial involving 4700 ewes in 21 flocks in the Hawkes Bay, autumn-lambing ewes were found to have a multiple birth rate of 21% compared to 51% for spring-lambing ewes (Grace *et al.* 1989). Similar results have been reported under Australian conditions where spring-lambing ewes had a higher multiple birth rate than winter-lambing ewes which in turn had a higher rate than autumn-lambing ewes (Fitzgerald 1976).

Lambs born to spring-lambing ewes have been found to be heavier at birth than those born to autumn-lambing ewes (Quinlivan 1988; Reid *et al.* 1988; Peterson *et al.* 1990). Cruickshank & Smith (1989), in a study of all-year lamb production, recorded birth weights bi-monthly and noted that lambs born in January and March were lighter than those born in May, September and November. The difference in their study between May- and September-born lambs (4.3 ± 0.2 v. 4.8 ± 0.1 kg) was, however, statistically non-significant. Other researchers have reported no differences in birth weight between autumn- and spring-born lambs (Rumball 1980; Andrewes 1983).

Autumn-born lambs usually have lower mortality rates than spring-born lambs (Andrewes 1983; Reid *et al.* 1988; Thompson & Obst 1989). McQueen (1986) recorded a mortality rate (within 24 hours of birth) of 7.3% in autumn-born lambs compared to 15.2% in spring-born lambs. Contrary to these findings, McNeal (1978) found, in a USA research programme, a higher death rate in autumn-born than in spring-born lambs (both run under range conditions). Other researchers have recorded no differences in lamb mortality and subsequent weaning rate between spring- and autumn-born lambs (Reid *et al.* 1988). These inconclusive differences in lamb mortality and number of lambs reared between spring- and autumn-born lambs are to be expected as factors such as litter size, herbage availability, ewe condition and climatic conditions at lambing can influence differences in mortality rates between seasons.

Spring-born lambs were reported by Andrewes (1983) to be heavier at weaning over a period of 4 years (by 2.5-4.9 kg) than their autumn-born counterparts. In the trial of Cruickshank & Smith (1989), the pre-weaning growth rate of September-born lambs was 276 g/d compared to 233 g/d for their May-born peers. Andrewes & Taylor (1986) found that there was little difference in the pre-weaning growth rates of spring- and autumn-born lambs (235 v. 230 g/d).

Intakes of superior quality herbage, rising ambient temperatures and photoperiod change could all contribute to the increased growth rates of spring born-lambs. Ewe milk production may also be a contributing factor and data to support this comes from the study of Peterson *et al.* (1990) who recorded a lower milk production in autumn-lambing ewes compared to spring-lambing ewes. The effect of daylength on lamb growth rates has been well documented (Forbes *et al.* 1975; Schanbacher & Crouse 1980; Barenton *et al.* 1988; Ebling *et al.* 1989; Lincoln 1990). The mechanisms are not fully understood but are likely to involve different patterns of melatonin secretion and associated increases in circulating growth hormone and/or prolactin concentrations during periods of increasing daylength (Barenton *et al.* 1988).

In summary, any system of autumn- or winter-lambing is likely to result in fewer and lighter lambs born, slower pre-weaning lamb growth rates and a lower weight of lamb weaned per ewe mated compared to a spring-lambing system.

Effects on Wool Production

Income from wool comprises 30-70% of the total income on New Zealand sheep farms (NZMWBES 1991). Therefore any effect that out-of-season lamb production has on wool production could potentially influence total farm income.

Australian research has shown no effect of season of lambing (winter v. spring or autumn v. spring) on ewe wool production (Allden 1956; Kenney & Davis 1975; Arnold *et al*. 1984). However, autumn-lambing ewes in New Zealand have been found to produce about 0.2 kg (clean wool weight basis) higher annual wool production than spring-lambing ewes (Reid *et al*. 1988; Reid & Sumner 1991). These researchers also noted that wool growth rate during the winter months (June and July) was higher in lactating autumn-lambing ewes than in their pregnant spring-lambing counterparts. The only period in which wool growth rate was higher in spring-lambing than in autumn-lambing ewes was during September and early October, after weaning of the autumn-lambing ewes and during lactation in those lambing in the spring. The peak wool growth rate in that trial was reached in late spring and was higher in the weaned autumn-lambing ewes than in the lactating spring-lambing ewes. Autumn-lambing ewes were therefore able to maintain wool growth rate while they were lactating and losing liveweight. Reid *et al*. (1988) suggested that autumn-lambing ewes were able to repartition protein and energy to wool production at the expense of liveweight over autumn and winter. These results need to be treated with caution as there is likely to be confounding between lambing date and nutritional regimens imposed on the ewes.

The study of Reid & Sumner (1991) indicates that autumn-lambing ewes do not show a marked seasonal decline in wool growth during the winter months. New Zealand sheep normally exhibit an inherent seasonal cycle of wool growth with a summer maximum and a winter minimum (Story & Ross 1960; Sumner & Wickham 1969; Bigham *et al.* 1978b; Sumner 1983; Geenty *et al.* 1984). The seasonal cycle of wool growth interacts with nutrition, resulting in a curvilinear relationship between wool growth and pasture allowance within each season (Hawker *et al.* 1984). The absolute response of wool growth rate to an increasing plane of nutrition was, however, much greater in summer than in winter (5.5 v. 2.3 g/d per extra 1000 g/d of high quality pelleted diet) but in relative terms the responses (54% v. 48%) were similar (Hawker & Crosbie 1985). The decreased wool growth measured during winter was due to both a decreased fibre length growth rate and to a reduced fibre diameter. The decreased diameter resulted in an increased susceptibility to tender or lower tensile strength wool. Sheep producing tender wool also tended to have lower fleece weights than those producing sound or high tensile strength wool when managed under similar conditions (Hight *et al.* 1976; Bigham *et al.* 1978a; Bigham *et al.* 1983b; Hawker & Crosbie 1985).

Therefore, if autumn-lambing does increase wool growth over the winter period there may be an associated benefit in certain wool quality traits such as tensile strength. Hawker & Littlejohn (1989) found that for a 1 g/d increase in wool growth during the July and August period staple strength improved by 3.3 N/Ktex. These researchers also noted that ewes growing fleeces of low staple strength had a more pronounced seasonal pattern of wool growth than ewes growing sound (high tensile strength) fleeces. Reid & Sumner (1991) found that wool from spring-lambing ewes was finer and had a markedly lower tensile strength than wool from autumn-lambing ewes.

Fleeces of October-shorn autumn-lambing ewes were coarser (by 1.1 μm), brighter (by 1.8 Y units) and less yellow (by 1.0 Y-Z units) than fleeces of October-shorn spring-lambing ewes (Reid & Sumner 1991). Wool bulk did not exhibit a definite seasonal trend (Sumner 1983) indicating that lambing date probably had little or no effect on wool bulk values.

On the basis of price trends over the last five years (Maddever *et al.* 1991) the net wool returns from autumn-lambing ewes would exceed those from spring-lambing ewes by approximately 80 cents per head (Reid & Sumner 1991). This differential reflects the increased wool weight and reduced level of processing faults found in wool from autumn-lambing ewes. While there have not been large gains reported in wool production from out-of-season lambing ewes there are gains which are additive to any other premiums that may be offered for out-of-season lambs. Any attempt to evaluate out-of-season systems should therefore examine the effect of lambing date on wool production and wool quality traits as well as on lamb production.

Nutritional Requirements and Feed Management

The performance of ewes and lambs at pasture is limited in the main by their intake of metabolisable energy (ME). The ME requirement is determined both by the net energy requirement for the processes of maintenance, growth, pregnancy and lactation, and by the efficiency (K value) with which ME is used for these purposes (Rattray 1986). It is well recognised that both climatic effects and feed quality can markedly affect the efficiency of ME use for maintenance and production (ARC 1980).

Autumn- or winter-lambing ewes lactate during the winter in cold conditions, when an increase in heat production may be required to maintain body temperature. In the short term, energy requirements for maintenance can be increased two- to three-fold (Brookes & Barry 1986). Furthermore, it has been found that sheep grazing autumn and winter pasture often show reduced growth rates compared with those on spring pastures, even though feed quality (as assessed by traditional methods) is similar (Scott *et al.* 1976). It has been suggested that this effect is due to a decrease in efficiency of ME use for maintenance and growth associated with reduced levels of soluble carbohydrate and increased levels of crude protein in autumn pasture (Armstrong 1981).

It is therefore highly likely that ewes lambing in May or June would have different feed requirements and hence herbage intakes when consuming herbage of a similar mass or height as August-lambing ewes. In the absence of any definitive evidence, Brookes & Barry (1986) calculated a range of K values for maintenance, growth and lactation for autumn pastures for use in a simulated study of the feed requirements of an autumn-lambing flock. Currently there are no indirect or direct estimates of herbage intake of autumn- or winter-lambing ewes under New Zealand pastoral conditions. Likewise, relationships between sward surface height (SSH) or herbage allowance and production are unknown for pregnant or lactating autumn- or winter-lambing ewes. This is reflected in the published feed budgeting and modelling exercises for autumn-lambing systems in which ewes lambing in autumn are assumed to have the same feed requirements as those lambing in the spring (Barlow 1986; McCall & Bywater 1987; Finlayson *et al.* 1990). In some case theoretical adjustments based on differences in feed utilisation values have been made to account for the differences between autumn and spring pasture (Brookes & Barry 1986; Hawkins *et al.* 1989).

The problem of measuring herbage intake in grazing sheep in New Zealand has largely been avoided by examining directly the relationship between herbage allowance (the amount of herbage offered) and production (Rattray *et al.* 1987). In some experiments the residual herbage mass remaining after the sheep have been removed has also been estimated and from this the proportion of the offered herbage apparently eaten, and hence average intakes, have then been calculated (Monteath 1971; Rattray 1978b; Rattray & Jagusch 1978; Rattray *et al.* 1982b; Smeaton & Rattray 1984).

Feed budgeting, as it is used in intermittent grazing systems (Milligan *et al.* 1987), has stemmed from information on the herbage intake and production of various stock classes and liveweights in relation to either herbage allowance or estimated feed requirements. Where continuous stocking is the grazing method, the herbage allowance method is almost impossible to use unless some estimates of herbage growth are also obtained. On most New Zealand farms continuous stocking is the normal practice from lambing to weaning. Hence use of the herbage allowance method to allocate pasture to livestock may be only a limited aid to grazing management throughout this period. Sward surface height or herbage mass may provide a more meaningful description of the relationship between sward conditions and productivity under these continuous stocking systems (Corbett 1980; Hodgson 1981; Hodgson & Maxwell 1984; Hodgson 1986; Webby & Pengelly 1986; Parker & McCutcheon 1992).

Late pregnancy and lactation are two critical periods of the production cycle that farmers need to consider when changing a proportion of their spring-lambing flock to autumn- or winter-lambing. Responses to increasing nutrition (in terms of lamb and ewe weaning weights and wool production) have been described for late pregnancy (Coop 1950; Coop & Clark 1969; Monteath 1971; Rattray *et al.* 1982a; Smeaton *et al.* 1983; Smeaton & Rattray 1984; Geenty & Sykes 1986) and for lactation (Coop *et al.* 1972; Sumner 1979; Hawker *et al.* 1982; Rattray *et al.* 1982b; Munro & Geenty 1983; Parker & McCutcheon 1992) in spring-lambing ewes. No such experiments have been performed on autumn- or winter-lambing ewes. The general recommendation for spring-lambing ewes is that lamb growth per hectare is maximised at a herbage mass of 1200-1500 kg DM/ha or a sward surface height (SSH) of 5-6 cm (Milne *et al.* 1981; Hodgson & Maxwell 1984; Penning & Hooper 1985; Parker & McCutcheon 1992). The majority of the nutritional regimens imposed on ewes during pregnancy under New Zealand pasture feeding conditions have had minimal effects on lamb production because mobilisation of maternal body reserves often compensates for underfeeding in late pregnancy when ewes enter this period in good body condition (Rattray & Trigg 1979). Therefore, if pasture shortages are likely just after lambing, sub-optimal feeding during late pregnancy to conserve pasture for the post-lambing period should not have marked detrimental effects on lamb production (Smeaton *et al.* 1985). This may or may not be the case for autumn- or winter-lambing ewes and certainly needs to be tested under field trial conditions before feed strategies based on spring-lambing ewes can be used in autumn- or winter-lambing systems.

The voluntary intake and nutritional requirements of sheep have generally been established with housed animals. Although intake data from housed animals may apply to grazing animals, pasture conditions such as height, density and quality can have major effects on the determinants of intake, ie biting rate, intake per bite and grazing time (Allden & Whittaker 1970). Bite size is the component of rate of intake (biting rate x bite size) most sensitive to sward changes and declines as herbage mass or sward surface height decrease (Allden & Whittaker 1970; Jamieson & Hodgson 1979; Hodgson 1981; Black & Kenney 1984; Hodgson 1985; Penning 1986; Burlison *et al.* 1991). Although grazing time and biting rate may be increased by sheep in an attempt to compensate, intake is normally reduced under conditions of low herbage mass or sward surface height (Black & Kenney 1984; Burlison & Hodgson 1985; Penning 1986; Forbes 1988; Dougherty *et al.* 1989; Mursan *et al.* 1989; Orr *et al.* 1990; Hughes *et al.* 1991; Penning *et al.* 1991). This is particularly so on continuously stocked swards where the critical sward surface height at which intake becomes limited is between 3.0 and 6.0 cm (Bircham 1981; Penning 1986). However, intake of pasture may also be limited by the time available for eating and ruminating, especially when the rate of dry matter intake is low. Sheep generally spend 6 to 10 hours per day grazing with the actual duration dependent on pasture availability, day length and ambient temperature (Arnold 1981; Penning & Hooper 1985). These conditions will vary considerably from autumn to spring and may therefore contribute to differences in ingestive behaviour and herbage intake. Relationships between ingestive behaviour and production are well documented for spring-lambing ewes (Penning 1986; Hodgson 1990) but there are no such measurements available for pregnant or lactating autumn- and winter-lambing ewes stocked under New Zealand pastoral conditions. Collection of such information would assist in explaining differences in herbage intake in relation to pasture conditions and in determining relationships for autumn/winter-lambing ewes similar to those currently available for spring-lambing ewes.

PURPOSE AND SCOPE OF THE INVESTIGATION

As indicated earlier, there is good reason to believe that New Zealand sheep farmers will increasingly be required to produce lambs on a year-round basis. This will necessitate the development of out-of-season lambing systems. Although such systems have been developed in some regions of New Zealand (eg Northland and Hawkes Bay) they have not been studied in other areas of New Zealand. Furthermore, there has been little attempt to examine in detail the relationship between herbage allowance and production of out-of-season lambing ewes.

The objective of this study is therefore to evaluate out-of-season lambing systems for the lower North Island of New Zealand. Specific objectives were as follows:

1. **To investigate three ewe crosses for out-of-season lambing.**

Three ewe crosses were evaluated under commercial farming conditions in this part of the programme: the Border Leicester x Romney (BR), a cross commonly used to produce prime lambs in the lower North Island; the Poll Dorset x BR (PBR), which allowed the potential impact of the Poll Dorset crosses, which have a long breeding season and good milking ability, to be evaluated; and the Suffolk x BR (SBR), an unconventional cross but one whose inclusion was justified by the fact that Suffolk crosses are commonly used as dams of prime lambs in the United Kingdom (Read 1982), United States of America (Terrill 1982) and Canada (Fahmy & Vesely 1977). In the Canadian situation Suffolk ewes are considered to have a relatively long breeding season (Fahmy & Vesely 1977) but no comparable data are available in New Zealand.

Three groups of hoggets, representing each of the ewe-breed crosses and three birth-years, were evaluated for hogget wool production, growth and hogget oestrus under commercial farming conditions (Chapter II). The effects of ewe-breed cross and lambing policy (June v. August) on wool and lamb production were then evaluated at the 2-year-old (1987, 1988 and 1989) and 3-year-old (1988, 1989 and 1990) lambings. Ewe and lamb liveweights were recorded throughout the year and wool production of ewes was measured on an annual basis. All trial ewes were managed under commercial farming conditions (Chapter III).

2. To determine the pattern of wool production in winter- and spring-lambing ewes.

Results of the field evaluation trials described above showed that winter-lambing ewes produced more wool on an annual basis than spring-lambing ewes, an effect consistent with previous literature reports (see pages 20-22). The monthly patterns of wool growth in ewes lambing under the two policies were therefore investigated in an attempt to identify times of year when these differences occurred and how these changes affected wool quality (Chapter IV).

3. To determine herbage allowance/intake/production relationships appropriate to winter-lambing ewes.

Two studies were undertaken to examine the relationship between herbage allowance, ewe intake and productivity in lactating winter-lambing ewes (Chapter V), and in pregnant winter- and spring-lambing ewes (Chapter VI).

CHAPTER II

EVALUATION OF BORDER LEICESTER X ROMNEY (BR), POLL DORSET X BR AND SUFFOLK X BR EWES FOR OUT-OF-SEASON LAMBING:

1. PERFORMANCE OF REPLACEMENT EWE HOGGETS

ABSTRACT

Border Leicester x Romney (BR), Poll Dorset x BR (PBR) and Suffolk x BR (SBR) ewe hoggets that were being reared to enter an out-of-season lambing experiment were evaluated for liveweight, yearling greasy fleece weight and occurrence of oestrus in three successive years. Suffolk x BR hoggets were significantly ($P<0.01$) heavier than PBR and BR ewe hoggets post-mating (May), post-shearing (October) and in January (at about 16 months of age). There were inconsistent differences in liveweight between PBR and BR ewe hoggets. Border Leicester x Romney hoggets produced significantly ($P<0.01$) more greasy wool at the yearling shearing than PBR or SBR hoggets, while PBR hoggets had the highest percentage (42-69%) displaying oestrus over two cycles of mating ($P<0.01$). A simple economic evaluation of returns from hoggets of the three ewe crosses indicated that differences in production translated into an average advantage to the BR hoggets of approximately $1.80/yr compared with the SBR or PBR hoggets. This small advantage to the BR in hogget performance would be reduced if potential breeding as a hogget was taken into account.

INTRODUCTION

Ewe hoggets comprise 27% of New Zealand's sheep numbers (NZMWBES 1991) while on individual farms 10-15% of the total stock units farmed can be hoggets. The choice of breed for an out-of-season lambing system will affect farm returns not only through its influence on ewe performance but also through any differences in performance of replacement ewe hoggets.

Factors that contribute to hogget performance include liveweight, fleece weight and hogget oestrus. Liveweight is important because of its relationship with subsequent ewe performance (Dyrmundsson 1973, 1981; Hight & Jury 1976). Furthermore, ewe hoggets surplus to requirements are usually sold for slaughter or as store animals to other farmers, with heavy hoggets realising higher prices than light hoggets. Hogget fleece weight can contribute up to 15% of the returns for New Zealand sheep farms. Therefore ewe hoggets from breeds or crosses that clip high fleece weights and/or high value wool are desirable.

Hogget oestrus is important because it is related to the potential benefits obtained from breeding ewe hoggets (Hulet *et al.* 1969; Dyrmundsson 1973; Hight & Jury 1976; Baker *et al.* 1978; Levine *et al.* 1978). The incidence of hogget oestrus provides an indirect assessment of the ability of different breeds and crosses to lamb as a hogget. However, ewes that enter an early lambing flock (January mating) are unlikely to be considered for hogget mating as their normal 2-year-old mating would be advanced from 18 months of age to 16 months of age or earlier. Thus an evaluation of the suitability of different breeds and crosses for alternative sheep production systems (eg lambing dates) should also include the potential value of hogget lambing. Decisions on which particular breed or cross to use must therefore be based on total production from the ewe hogget through to the adult ewe.

The objective of this experiment was therefore to evaluate three different types of crossbred ewe hoggets that were being reared to enter an out-of-season lambing experiment (Chapter III). Border Leicester x Romney (BR), Poll Dorset x BR and Suffolk x BR ewe hoggets were evaluated for liveweight, yearling greasy fleece weight and occurrence of oestrus in three successive years. Information from this experiment and subsequent experiments (Chapters III & IV) using the same sheep was expected to assist in identifying which of these ewe crosses are most suited to an out-of-season breeding programme in the lower North Island.

MATERIALS AND METHODS

The trial was conducted at Massey University's Keeble Farm (latitude 40° 10'S), 5 km south of Palmerston North. Ewe lambs of the Border Leicester x Romney (BR), Poll Dorset x BR (PBR) and Suffolk x BR (SBR) crosses were run together from mid-April until early January (when they entered the ewe flock) and evaluated for liveweight, hogget oestrus and yearling fleece weight. The trial was repeated over three years (1986, 1987 and 1988).

The ewe hoggets originated from three separate sources. They were all transferred to Keeble Farm in early January when they were approximately 4 months old. The SBR hoggets originated from within the Keeble Farm flock where the mean lambing date was 25 August. The PBR group originated from a Waipukurau farm where the mean lambing date was 20 August and the BR ewe hoggets came from the flock of a Wairarapa property mean lambing date was 5 September. The numbers of hoggets of each cross used in each year are shown in Table 2.1.

During the pre-experimental period (from early January until mid-April) the ewe hoggets were rotationally grazed ahead of the ewe mob under *ad libitum* feeding conditions. Throughout this period they were drenched at four week intervals with Levamisole (Nilverm, Coopers-Pitman-Moore, New Zealand Ltd). In 1986 and 1987 the ewe hoggets were shorn on 4 and 5 April, respectively, to eliminate the effect of different lamb shearing dates. However, in 1988 lamb shearing occurred in the same week (11-15 December) on each of the properties and only a pre-mating crutch on 17 April 1988 was considered necessary.

Table 2.1 Numbers of Border Leicester x Romney (BR), Poll Dorset x BR (PBR) and Suffolk x BR (SBR) hoggets entering the trial each year.

	BR	PBR	SBR
1986	208	205	201
1987	137	143	143
1988	130	144	134

The ewe hoggets grazed a separate area of Keeble Farm from mid-April through to mid-November. They were stocked at 16 hoggets/ha and the objective was to maintain moderate growth rates (ca. 50-100 g/d) over the winter by leaving a post-grazing residual herbage mass of 600-700 kg DM/ha. Once pasture growth rates had increased in the spring, post-grazing residual mass was increased to at least 1200 kg DM/ha to accommodate a liveweight gain target of 200 g/d. From mid-November the ewe hoggets entered a whole farm rotation, behind the weaned lambs and ahead of the mixed-aged ewes. Pasture mass was assessed fortnightly using the Ellinbank Pasture Meter (Earle & McGowan 1979). A calendar of events for the hoggets is shown in Table 2.2.

Table 2.2 Calendar of events for hoggets entering the trial in 1986, 1987 and 1988.

Event	1986	1987	1988
Teaser ram joining	16 April	20 April	20 April
Ram removal	20 May	21 May	22 May
October weight	3 October	4 October	30 October
Shearing	20 November	23 November	26 October
January weight	6 January	6 January	6 January

Vasectomized 2-year-old Suffolk x (Border Leicester x Romney) rams were joined with the ewe hoggets at a ratio of 1:50. The rams were each fitted with a sire-sine marking crayon (Radford *et al.* 1960) and were inspected every second day to ensure that the harnesses were correctly fitted. Crayon colour was changed after one cycle (16 days) of mating. Mating crayon marks were recorded on days 16 and 32 of mating.

Liveweight and Fleece Weights

Unfasted hogget liveweights were recorded at ram joining (mid-April), ram removal (late May), October and January. Hoggets were weighed within one hour of leaving pasture using electronic load bar scales (Tru-Test Distributors Ltd, Auckland). The October 1988 liveweight was adjusted by adding the fleeceweight but 1986 and 1987 October weights were recorded prior to shearing (Table 2.2).

Yearling greasy fleece weights (including belly wool) were recorded at the spring shearing. The 1986 and 1987 greasy fleece weight represented 7 months of wool growth while the 1988 greasy fleece weight represented 10 months of wool growth.

Statistical Methods

Hogget liveweights and yearling fleece weights were analysed using the univariate analysis of variance to test the effects of cross, year and their interaction. October liveweight was fitted as a covariate to reduce the error variance in the fleece weight model. Ewe cross effects were treated as fixed while year effects were regarded as random. The model used to analyse fleece weight and liveweight was therefore a mixed model and the error term used to test the cross effect was the cross x year interaction term (Snedecor & Cochran 1967). Results of the liveweight analyses must be interpreted with caution in recognition of the fact that sequential weighings represented repeated measurements on the same animals (Gill & Hafs 1971).

The model was:

$$Y_{ijk} = \mu + C_i + T_j + CT_{ij} + b(X_{ijk}) + e_{ijk} \qquad \textit{[Model 2.1]}$$

where Y_{ijk} = an observation of fleece weight or liveweight on the *k*th ewe hogget of the *i*th cross in the *j*th year.

μ = the general mean

C_i = the fixed effect of the ith cross ($i = 1...3$)

T_j = the random effect of the *j*th year ($j = 1..3$)

CT_{ij} = the interaction of the *i*th cross with the *j*th year

b = the pooled regression coefficient of fleeceweight (*Y*) on October liveweight (*X*)

X_{ijk} = October liveweight of the *k*th ewe hogget of the *i*th cross in the *j*th year

e_{ijk} = the random residual associated with an observation on the *k*th ewe hogget of the *i*th cross in the *j*th year

Differences between group means were tested according to pre-planned comparisons using t-tests (Snedecor & Cochran 1967). Data were expressed in terms of means (±SEM). Interaction terms that were not significant ($P > 0.05$) were deleted from the model and the model refitted.

The occurrence or non-occurrence of oestrus was analysed as a binomial trait using the Statistical Analysis System (SAS 1985) computer package procedure for categorical data modelling (CATMOD). CATMOD uses maximum likelihood estimation of parameters for log-linear models and the analysis of generalised logits. The model was similar to Model 2.1 except that liveweight prior to mating (April) was fitted as a covariate to reduce the error variance. Differences between group means were tested according to pre-planned comparisons using the Chi-Square statistic (SAS 1985).

RESULTS

Hogget Liveweight

Suffolk x BR ewe hoggets were heavier than PBR and BR ewe hoggets prior to hogget mating in 1987 and 1988 while in 1986 there was no difference between SBR and PBR ewe hoggets but these two breeds were significantly ($P<0.05$) heavier than BR ewe hoggets (Fig. 2.1). The SBR ewe hoggets were heavier than the PBR and BR ewe hoggets post-mating (late May), post-shearing (October) and at the January weight. In 1986 and 1987 the PBR ewe hoggets were heavier than BR ewe hoggets at each weighing. However, in 1988 the BR ewe hoggets were heavier than PBR ewe hoggets prior to and just after mating but there was no difference between these two breeds at the 1988 post-shearing and January weights.

Ewe hoggets that cycled were heavier than acyclic hoggets in 1986 and 1988 but this was not the case in 1987 (significant interaction, $P<0.05$) (Table 2.3). Border Leicester x Romney and PBR cyclic hoggets were heavier than acyclic hoggets of these breeds, but there was no difference in liveweight between cyclic and acyclic SBR hoggets (significant interaction, $P<0.05$) (Table 2.3).

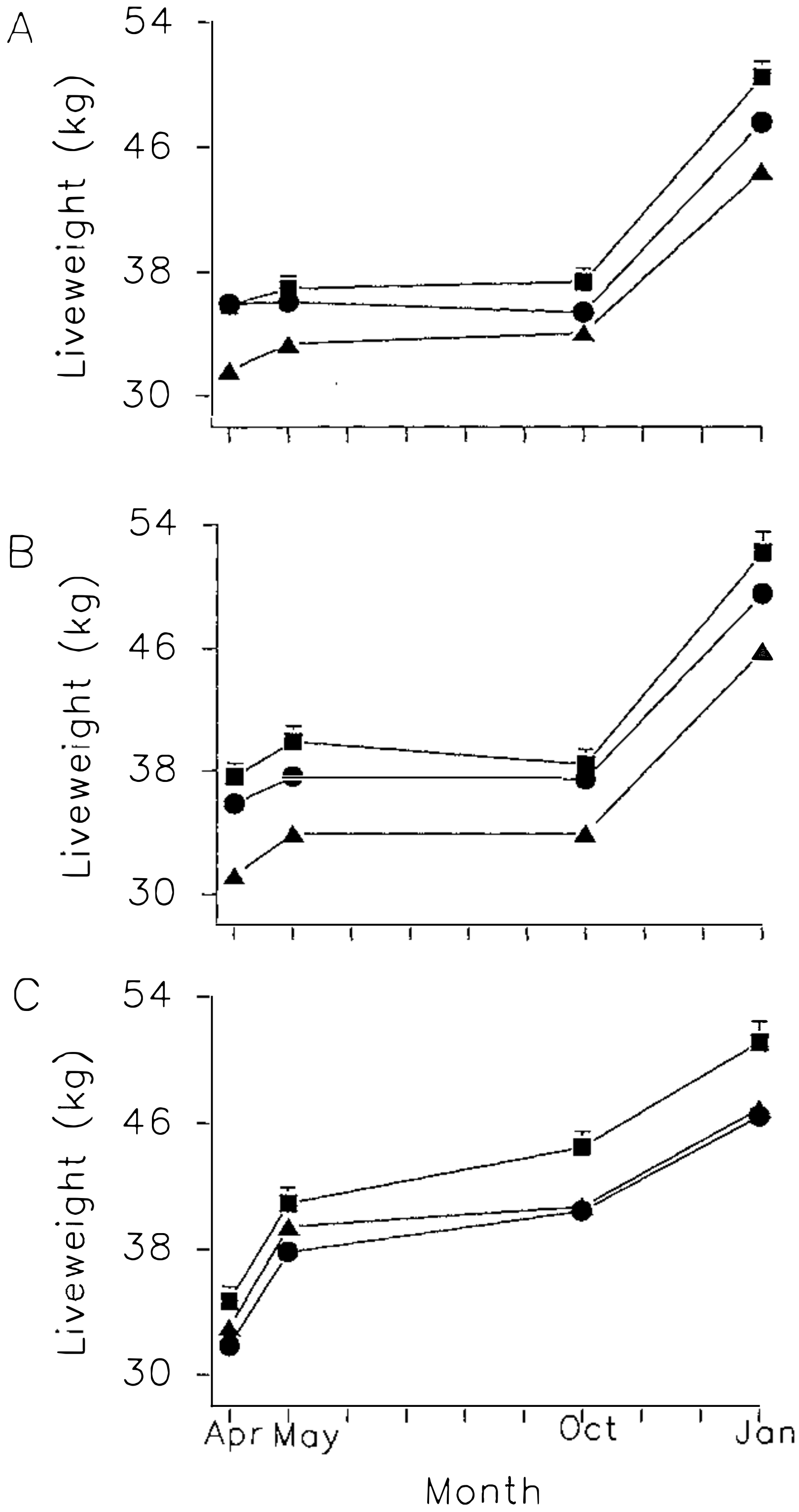

Fig 2.1 **Mean liveweights (±SEM) of Border Leicester x Romney (BR) (▲), Poll Dorset x BR (PBR) (●) and Suffolk x BR (SBR) (■) ewe hoggets in 1986(A), 1987(B) and 1988(C). Vertical bars represent the pooled standard error at each time.**

Table 2.3 **Effect of year and cross on post-mating liveweights of cyclic and acyclic ewe hoggets (Mean ± SEM).**

	Cyclic		Acyclic	
	No.	**Liveweight (kg)**	**No.**	**Liveweight (kg)**
Year				
1986	262	36.2 ± 0.1^{b}	338	34.6 ± 0.2^{a}
1987	217	37.3 ± 0.3^{c}	201	37.0 ± 0.3^{c}
1988	145	40.2 ± 0.3^{e}	258	38.8 ± 0.2^{d}
Cross[1]				
BR	119	36.2 ± 0.2^{b}	348	35.2 ± 0.2^{a}
PBR	272	38.0 ± 0.3^{c}	211	36.2 ± 0.2^{b}
SBR	233	39.5 ± 0.2^{d}	238	39.1 ± 0.2^{d}

1 BR = Border Leicester x Romney, PBR = Poll Dorset x BR, SBR = Suffolk x BR.
abcde Means within main effects having superscripts with letters in common are not significantly different (P > 0.05).

Wool Production

Border Leicester x Romney ewe hoggets produced significantly (P < 0.001) more greasy wool at the yearling shearing than either PBR or SBR hoggets (Table 2.4). The advantage to BR ewe hoggets over PBR ewe hoggets was 0.4, 0.3 and 0.8 kg, while PBR hoggets were superior to SBR hoggets by 0.2, 0.4 and 0.4 kg, in 1986, 1987 and 1988 respectively. This was reflected in a significant (P < 0.001) cross x year interaction. Hogget yearling fleece weight was unaffected by the occurrence or non-occurrence of oestrus the previous autumn.

Table 2.4 Effect of cross within year on hogget fleece weight (Mean±SEM).

	Fleeceweight (kg)		
	1986	1987	1988
Cross[1]			
BR	2.4±0.2[c]	3.0±0.3[f]	3.3±0.4[g]
PBR	2.0±0.2[b]	2.7±0.2[e]	2.5±0.4[d]
SBR	1.8±0.2[a]	2.3±0.3[c]	2.1±0.4[b]

[1] BR = Border Leicester x Romney, PBR = Poll Dorset x BR, SBR = Suffolk x BR. For numbers see Table 2.1.
[abcdefg] Means having superscripts with letters in common are not significantly different (P>0.05).

Oestrus Behaviour

The proportion of ewe hoggets exhibiting behavioural oestrus during the first cycle of mating is shown in Table 2.5. There was a significant (P<0.05) cross x year interaction. A higher proportion of Suffolk x BR hoggets were in oestrus after the first cycle in 1987 compared to PBR hoggets, but in 1986 and 1988 there was no difference in the proportion in oestrus between these two crosses. In all years, SBR and PBR hoggets exhibited a higher incidence of oestrus than BR hoggets.

Table 2.5 Effect of cross within year on the proportion of ewe hoggets exhibiting oestrus in one cycle of mating.

	Proportion Showing Oestrus (%)		
	1986	1987	1988
Cross[1]			
BR	- 2.986±0.324[2b] (5)[3]	-4.913±1.001[a] (1)	-2.866±0.389[b] (5)
PBR	- 1.725±0.195[c] (15)	-1.759±0.236[c] (15)	-1.946±0.252[c] (13)
SBR	- 1.664±0.193[c] (16)	-1.326±0.205[d] (21)	-2.319±0.303[bc] (9)

[1] BR = Border Leicester x Romney, PBR = Poll Dorset x BR, SBR = Suffolk x BR. For numbers per group see Table 2.1.
[2] Logit-transformed.
[3] Back-transformed (%).
[abcd] Means having superscripts with letters in common are not significantly different (P>0.05).

The percentages of PBR hoggets displaying oestrus over two cycles of mating (Table 2.6) ranged from 42-69% while among for the SBR and BR hoggets equivalent figures were 29-62% and 21-34%, respectively. There was also a significant ($P<0.001$) cross x year interaction indicating that the ranking of crosses for incidence of hogget oestrus varied between years.

Table 2.6 Effect of cross within year on the cumulative proportion of ewe hoggets exhibiting oestrus in two cycles of mating.

	Proportion Showing Oestrus (%)		
	1986	1987	1988
Cross[1]			
BR	-1.287 ± 0.168^{2a} (22)[3]	-1.315 ± 0.209^{a} (21)	-0.636 ± 0.184^{bc} (34)
PBR	0.206 ± 0.140^{d} (55)	0.811 ± 0.181^{a} (69)	-0.307 ± 0.169^{c} (42)
SBR	0.089 ± 0.141^{d} (52)	0.529 ± 0.173^{a} (62)	-0.854 ± 0.189^{b} (29)

1 BR = Border Leicester x Romney, PBR = Poll Dorset x BR, SBR = Suffolk x BR. For numbers per group see Table 2.1.
2 Logit-transformed.
3 Back-transformed (%).
abcda Means having superscripts with letters in common are not significantly different ($P>0.05$).

DISCUSSION

Liveweight

Suffolk x BR ewe hoggets were the heaviest of the three crosses at the January weighing in each year of the trial. This is presumably a reflection of the large mature size of the Suffolk breed compared to the Poll Dorset, Border Leicester or Romney breeds (Carter & Kirton 1975; Carter & Cox 1982). The PBR ewe hoggets were heavier than the BR ewe hoggets at the January weighing in 1987 and 1988, but in 1989 there was no difference between these two crosses. Thus in terms of prices for ewe hoggets culled onto the meat trade, SBR hoggets would be superior to the other crosses while differences between the BR and PBR hoggets are smaller and inconsistent.

Other researchers have found that Suffolk-sired lambs were heavier than Border Leicester-sired lambs at 6 months of age (Coop & Clark 1952; Coop & Clark 1957; Geenty & Clarke 1977). Carter & Kirton (1975), however, found that there was little difference in the ranking of Suffolk x Romney, Border Leicester x Romney and Dorset (Polled or Horn) x Romney lambs for 120 day weight. This reflects the Dorset's rapid early growth compared to the slower maturing Border Leicester or Suffolk (Carter & Cox 1982). McMillan *et al.* (1988) found that Suffolk x Romney, Border Leicester x Romney and Coopworth ewe hoggets had similar yearling weights.

Liveweight differences between the crosses at the start of the trial could also have reflected differences in management practices on their respective rearing farms rather than genetic differences. The net liveweight changes from 20 April to 6 January for the BR, PBR and SBR ewe hoggets were: 12.8, 11.6 and 14.6 kg in 1986; 14.6, 13.7 and 14.6 kg in 1987; and 13.9, 14.6 and 16.4 kg in 1988, respectively. Therefore when the crosses were run together in a common environment the SBR hoggets gained the most liveweight over each of the three years compared to the BR and PBR hoggets, while the differences between the BR and PBR hoggets were small and inconsistent.

Wool Production

Border Leicester x Romney ewe hoggets outperformed the SBR and PBR hoggets for hogget fleece weight in all years although the difference between crosses varied from year to year. The superiority of BR over Poll Dorset cross animals for wool production agrees with results of other studies. Sumner *et al.* (1981) measured annual wool production in Dorset x Romney hoggets of 2.87 kg compared with 3.07 kg in Coopworth hoggets. Clarke (1984) found that BR ewe hoggets clipped 1.55 kg wool in 11 months compared with 1.13 kg for Dorset x Romney hoggets. Most researchers have ranked Suffolk cross hoggets lower than Border Leicester or Poll Dorset cross hoggets for wool production (Carter & Kirton 1975; Rattray *et al.* 1976; Carter & Cox 1982). The lower wool production in SBR and PBR hoggets is negated to some extent by a higher price obtained for the increased bulkiness of Suffolk and Poll Dorset cross wool. However this advantage, at present, accounts for only an extra 10-20¢ per kg (W.R. Regnault, *pers. comm.*).

There was no difference in yearling greasy fleece production between cyclic and acyclic ewe hoggets. Conversely, McMillan (1981) found that cyclic BR hoggets produced more wool than acyclic hoggets (3.48 v. 3.04 kg) at yearling shearing. However that difference was confounded by a 10 kg difference in liveweight at shearing compared with only 1.1 kg in this trial.

Oestrus Behaviour

The levels of oestrus behaviour recorded in ewe hoggets in this trial (21-69%) were of the same order as those for hoggets of similar liveweight recorded by Ch'ang & Raeside (1957), 72%; Hight *et al.* (1973), 55%; Allison *et al.* (1975), 43%; Meyer & French (1979), 25%; and McClelland (1990), 57%. However, they were much lower than levels recorded by McMillan (1981) and Asofi (1984) of 89% and 85% respectively.

Breed differences recorded in this trial suggest that the PBR ewe hoggets are more precocious than BR ewe hoggets, although this advantage varied between years. Dalton (1978) found that, under North Island hill country conditions, 64% of Dorset x Romney ewe hoggets exhibited oestrus in their first autumn compared with 50% of Coopworth ewe hoggets. The proportion of SBR ewe hoggets exhibiting behavioural oestrus was very similar to that of the PBR ewe hoggets but greater than that of the BR ewe hoggets. Quirke *et al.* (1985) recorded the mean age of first oestrus in Dorset ewe hoggets as 234 days compared with 245 days in Suffolk ewe hoggets. The relatively low level of oestrus activity recorded in the BR ewe hoggets contrasts with the findings of McMillan (1981) that 89% of BR ewe hoggets experience oestrus in their first autumn. However, the hoggets in that trial weighed 39 kg compared with 33 kg for the BR ewe hoggets in this trial.

Year effects were significant ($P < 0.001$) for the proportion of hoggets that exhibited oestrus over two cycles but not for the proportion exhibiting oestrus in the first cycle of mating. However, the year effects varied according to breed. Lang & Hight (1967) found similar year effects with 55% of their hoggets showing oestrus in one year compared with 43% in the next year. The higher proportion of hoggets showing oestrus in the first two years of this trial could be a result of the autumn shearing. However Dyrmundsson & Lees (1972b) found that autumn shearing treatment did not have any consistent effect on the attainment of puberty and cyclic activity in ewe lambs.

The ram effect could be another explanation for the year effects on oestrus activity (Knight 1983). One report in literature suggested that the sudden introduction of rams into groups of pre-pubertal ewes did lead to oestrus synchronisation, but that the date of first oestrus was usually unaltered (Dyrmundsson & Lees 1972a). However the rams were introduced at similar dates each year and the proportion of hoggets showing oestrus in the first cycle did not vary between years, suggesting a minimal ram effect.

Ewe hoggets that cycled tended to be heavier than acyclic hoggets. Several studies have shown differences similar to the 1-3 kg observed in this trial (Ch'ang & Raeside 1957; Hight *et al.* 1973; Meyer & French 1979; Baker *et al.* 1981; McMillan 1981; McMillan & McDonald 1983; Asofi 1984; McClelland 1990). Bichard *et al.* (1974) reported a linear relationship between mating weight of ewe lambs (in 2-3 kg ranges from 25-60 kg) and the proportion of hoggets lambing in each range. Their regression coefficient, pooled over 15 years, predicted a 1.1% increase in number of hoggets lambing per kg increase in mating weight. However, there was a large variation in the regression coefficient between years (-0.7 to +3.8). Therefore the year and breed variations found in cyclic and acyclic hogget liveweights in this trial are to be expected.

Economic Evaluation

A simple economic evaluation of the returns from hoggets of the three ewe crosses was made by calculating average differences in net liveweight gain and fleece weight and assigning economic values to these differences. For the purposes of this exercise, 1 kg of liveweight gain was assumed to have a value of $0.50 (average price 1990/91 season), while 1 kg of greasy wool was valued at $3.10 for PBR and SBR wool and $3.00 for BR wool (average price 1990/91 season). The between-cross differences in incidence of hogget oestrus were not considered because, as noted earlier, hogget lambing is not practical in an out-of-season breeding policy. Hogget oestrus thus has a bearing on the value of different crosses only in situations where a proportion of the flock is lambed early and a proportion at the normal time.

Table 2.7 shows the results of this analysis. Over all three years, PBR hoggets gained 0.50 kg less, and SBR hoggets 1.40 kg more, liveweight than BR hoggets. Taking into account the value of 1 kg of liveweight gain (assumed constant in the three crosses) and the slightly different wool values, these differences translate into an average annual advantage to the BR hoggets of approximately $1.80/yr over the two other crosses. Relative to the gross margin for the BR hoggets this represents an extra 11% in average annual returns. Thus in terms of hogget performance alone, the BR was the superior cross. However, this difference was small, varied considerably between years (Table 2.7), and would be further minimised if potential breeding as a hogget were taken into account.

In summary, differences in hogget performance of the three ewe crosses studied were small and were not reflected in marked differences in estimated economic return during the rearing period. Thus the choice of cross most suitable for an out-of-season production system is likely to rest primarily on the performance of these crosses as mature ewes. A study evaluating these three crosses for wool production and as dams of June- and August-born lambs at the 2- and 3-year-old lambings is reported in Chapter III.

Table 2.7 Comparison of Border Leicester x Romney (BR) hoggets with Poll Dorset x BR (PBR) and Suffolk x BR (SBR) hoggets for yearly liveweight change, wool production and the relative economic value of the differences.

	BR	PBR-BR	SBR-BR
Liveweight gain (kg)			
1986	12.8	-1.2	+1.8
1987	14.6	-0.9	0.0
1988	13.9	+0.7	+2.5
Mean	13.8	-0.5	+1.4
Value[1]($)		-0.25	+0.70
Wool production (kg)			
1986	2.4	-0.4	-0.6
1987	3.0	-0.3	-0.7
1988	3.3	-0.8	-1.2
Mean	2.9	-0.5	-0.8
Value[2]($)		-1.55	-2.48
Total Value($)		-1.80	-1.78

1 Assumes 1 kg liveweight = $0.50.
2 Assumes 1 kg greasy wool = $3.10 for PBR and SBR wool, and $3.00 for BR wool.

CHAPTER III

EVALUATION OF BORDER LEICESTER X ROMNEY (BR), POLL DORSET X BR AND SUFFOLK X BR EWES FOR OUT-OF-SEASON LAMBING:

2. EWE PERFORMANCE IN AUGUST- AND OUT-OF-SEASON (JUNE)-LAMBING SYSTEMS

ABSTRACT

Border Leicester x Romney (BR), Poll Dorset x BR (PBR) and Suffolk x BR (SBR) ewes were evaluated for their out-of-season lambing potential. Three different year groups of ewes were evaluated for their 2-year-old (1987, 1988 and 1989) and 3-year-old (1988, 1989, 1990) lambing performance under both June- and August-lambing policies. Ewes were assigned to lambing policy (June or August) at their 2-year-old mating and remained within that policy throughout the trial. Mating (5 January for 3-year-old and 19 January for 2-year-old ewes) for the June-lambing ewes was induced using progesterone-impregnated controlled internal drug releasing devices (CIDR's) and high ram:ewe ratios. The two lambing policy ewe groups were managed similarly under commercial farming conditions.

Lambing policy did not influence the proportion of ewes lambing but there were more ($P<0.05$) multiple births in August-lambing ewes. Birth weights and weaning weights of June-born lambs were lower ($P<0.001$) than those of their August-born counterparts. June-lambing ewes produced more wool than August-lambing ewes but the magnitude of this difference varied between years (0.1-1.1 kg) reflecting a significant ($P<0.001$) policy x year interaction for fleece weight. Over all years and ages, the average annual greasy wool production advantage to June-lambing ewes was 0.5 kg.

Differences between the three ewe crosses in the proportion of ewes lambing and the incidence of multiple births were small and non-significant. Poll Dorset x BR ewes reared the heaviest lambs, while lambs from BR ewes were the lightest. Poll Dorset x BR ewes lost significantly ($P<0.01$) more liveweight during lactation than the other two ewe crosses. There was no difference in lamb losses between lambing policies or ewe crosses. Border Leicester x Romney ewes produced more wool (0.7 to 1.2 kg) than PBR ewes ($P<0.001$) while PBR ewes outperformed the SBR ewes (0.3 to 0.5 kg, $P<0.01$) for wool production.

An economic evaluation of returns (using 1990/91 costs and prices) from the ewe crosses indicated that production differences translated into average annual advantages to June-lambing BR ewes of $1.15 over PBR ewes and $2.37 over SBR ewes. The monetary differences between ewe crosses in the August-lambing policy were negligible. Individual ewe returns showed an advantage to June-lambing BR, PBR and SBR ewes over their August-lambing counterparts of $5.74, $4.73 and $2.96 respectively. If the stocking rates between the two policies were equated, then returns per hectare are likely to be similar for the two policies. It is concluded that, in a flock where a mix of August- and out-of-season (June)-lambing occurs, the BR ewes will perform better in terms of total economic returns than SBR or PBR ewes.

INTRODUCTION

Traditional lamb production in New Zealand has been driven by the pattern of herbage growth. Ewes are normally mated in autumn (March-May) so that they lamb at the beginning of the spring flush. Lambs are then ready for slaughter throughout the summer and autumn (December-May) and their carcasses exported in a frozen form.

The seasonal nature of the meat industry has been identified as a major limitation to increasing the value of New Zealand's lamb exports (Nordmeyer 1974; Taylor 1982; Johnson 1989). Large meat processing plants traditionally operated for no more than 8 months a year and this is a poor utilisation of capital plant and equipment. The proliferation of one-chain processing plants has further focused attention on efficiency, because these companies wish to keep their plants operating all year round. Some are even moving to two and three shifts per day. Out-of-season lambs are an ideal source of stock to meet these objectives of a year-round kill.

New developments in the chilled lamb trade enabling increased shelf storage life for chilled lamb of up to 16 weeks (Eriksen 1986; Chrystall *et al.* 1989) have allowed companies to ship chilled lamb cuts to the lucrative European and Southeast Asian supermarket trade. These supermarket chains require not only a quality product, but also continuity of supply and consistency of final presentation (Johnson 1989). A year-round supply of lambs will certainly benefit this emerging trade.

In the warmer areas of the North Island of New Zealand out-of-season lamb production has the additional appeal to farmers that it could allow a better utilisation of seasonal pasture supply (Rumball & Boyd 1980). Similarly in the drier East Coast regions of New Zealand out-of-season lamb production may be one method of farming for drought protection (Muir *et al.* 1989; Muir 1990).

An option for farmers to utilise out-of-season lambing is to mate cast-for-age ewes and/or wet/dry ewes in December to lamb in May (Lowe *et al.* 1988). This spreads the work operations on the farm, increases flexibility, improves cash flow, and adds to the pool of sheep available for killing in the off-season (since the cast-for-age ewes can be slaughtered after weaning in late August).

A major limitation to increased out-of-season lamb production is the restricted breeding season of most New Zealand sheep breeds. The majority of New Zealand sheep breeds commence oestrus activity in March and continue until July. Certain breeds and their crosses such as the Dorset (Newton & Betts 1967; Fogerty 1979; Phillips *et al.* 1984; Hall *et al.* 1986; Knight *et al.* 1989a; Knight *et al.* 1990) and the Merino (Smith *et al.* 1989a; Smith *et al.* 1989b; Knight *et al.* 1990) have the ability, albeit somewhat variable, to breed over extended seasons .

Hormonal techniques using a combination of progesterone pre-treatment and gonadotrophin administration to advance the breeding season have been available for a number of years (Robinson 1954) and are well documented under New Zealand conditions (Welch & Tervit 1970; Welch *et al.* 1971; Smith *et al.* 1988a; 1988b; Smith *et al.* 1989b). Although hormonal techniques can be used to induce out-of-season breeding, responses to these techniques may vary between breeds (Smith *et al.* 1989b) and between seasons (Quinlivan 1988; Smith *et al.* 1988b; Knight *et al.* 1989b). Hormonal techniques are costly relative to the value of lamb production so that some out-of-season breeding programs have attempted to use breeds and crosses with naturally longer breeding seasons (eg Dorset).

Documented evidence of success in this area has been provided in Northland using Dorset x Perendale (Andrewes & Taylor 1986) and Dorset x Romney (McQueen & Reid 1988; Reid *et al.* 1988) ewes. However, there are other consequences of using the Dorset such as lowered wool production (Bigham *et al.* 1978a; Clarke 1984) and a lowered fecundity compared to the Border Leicester x Romney (Hight & Dalton 1974; Dalton 1976). These disadvantages are offset to some extent by the superior milk production of the Dorset ewes which is reflected in higher progeny weaning weights (Geenty & Jagusch 1974).

The objective of this experiment was to evaluate the three ewe crosses described in Chapter II for their out-of-season lambing potential. Border Leicester x Romney (BR), Poll Dorset x BR (PBR) and Suffolk x BR (SBR) ewes were evaluated for lamb production, ewe liveweight change and fleece production throughout their 2-year-old and 3-year-old lambings under both June- and August-lambing programmes.

MATERIALS AND METHODS

Animals and Treatment

The trial was conducted at Massey University's Keeble Farm, (latitude 41° 10' S), 5 kilometres south of Palmerston North. The experimental design incorporated two lambing policies and three ewe crosses (ie a 2 x 3 factorial design). Three different groups of ewes were evaluated for their 2-year-old (1987, 1988 and 1989) and 3-year-old (1988, 1989 and 1990) lambings. The three ewe crosses have been described in Chapter II.

Within each cross, ewes were randomly assigned to a lambing policy (June v. August) prior to mating at 18 months-of-age. Ewes failing to lamb within their assigned policy as 2-year-olds were then removed from the trial prior to the 3-year-old mating. An exception to this was in 1989 when the barren 2-year-old ewes were retained for the 3-year-old mating within their respective policy (June v. August) to keep numbers at a comparable level to the previous year's matings. This was necessary because an outbreak of faecal eczema resulted in fewer ewes lambing as 2-year-old ewes. Numbers of 2-year-old ewes mated were 537, 378 and 327 in 1987, 1988 and 1989, respectively. The declining numbers in succeeding years also reflected a change in farm policy towards increased cattle numbers. Respective numbers of 3-year-old ewes mated were 467, 292 and 139 in 1988, 1989 and 1990.

Mating of the early lambing ewes (5 January for 3-year-old and 19 January for 2-year-old ewes) was accomplished using a combination of progesterone-impregnated controlled internal drug releasing devices (CIDR Type G, AHI Plastic Moulding Company, Hamilton, New Zealand) and high ram:ewe ratios (Bryant & Tomkins 1975). The CIDRs were inserted for 12 days and, 36 hours after CIDR removal, entire rams were introduced at a 1:10 ratio (Knight *et al.* 1989b). Mating was for two cycles using mixed aged Suffolk rams fitted with sire-sine marking crayons (Radford *et al.* 1960). Crayon colour was changed after the completion of each cycle when crayon marks were recorded.

Mating of the August-lambing groups commenced on 21 March using Suffolk rams for 2 cycles. All ewes were pregnancy-tested by ultrasound (Carter 1987) 40 days after ram removal and any non-pregnant ewes were removed from the trial (except in 1989, as described previously). A detailed calendar of major events subsequent to mating is given in Table 3.1.

Table 3.1 Calendar of events for June- and August-lambing 2-year-old and 3-year-old ewes.

Event	2-year		3-year	
	June	**August**	**June**	**August**
Rams joined	19 January	21 March	5 January	21 March
Rams removed	18 February	26 April	7 February	26 April
Pregnancy Test	30 March	20 June	22 March	20 June
Set-stock Lambing	10 June	19 August	26 May	19 August
Mid-Lambing	20 June	2 September	5 June	24 August
Shearing	19 October	19 October	19 October	19 October
Weaning	19 September	22 November	6 September	19 November

The two lambing policy groups were managed similarly (as far as possible) under commercial farming conditions. Each group was fed to increase liveweight over the mating period. This was achieved by shortening the rotation around paddocks and increasing the post-grazing residual dry matters. Once mating had been completed the ewes were returned to a slow rotation so that intakes could be restricted to maintenance levels. The target pasture cover for the lambing paddocks was set at 1200 kg DM/ha for both the June- and August-lambing groups. The June-lambing ewes were set-stocked at 8-10 ewes/ha while the stocking rate at lambing and during lactation for August-lambing ewes was 12-14 ewes/ha. The lower stocking rate of the June-lambing ewes was designed to take account of the lower winter pasture growth rates (Hawkins *et al.* 1989). During lactation, average pasture cover, measured fortnightly using the Ellinbank Pasture Meter (Earle and McGowan 1979), was kept above 1000 kg DM/ha by adding extra paddocks to the area available to the lambed ewes from other classes of stock on the farm. If pasture cover increased above 1500 kg DM/ha, which was the case in late spring for the August-lambing group, cattle were introduced to consume the excess pasture growth. After weaning, ewes were rotationally grazed to control intakes to maintenance levels or to achieve a small increase in ewe liveweight.

All ewes were drenched routinely at docking with ivomectin (Merck Sharp & Dohme NZ Ltd) and thereafter when average faecal egg counts of a sample of 10-20 ewes rose above 500-700 eggs per gram (epg). All ewes received a 5 in 1 clostridial vaccine (Covax, Coopers-Pitman-Moore New Zealand Ltd) prior to lambing. A severe outbreak of facial eczema during the autumn of 1989 seriously affected both the 2-year-old and 3-year-old ewes. A total of 60 (49%) June-lambing 2-year-old and 50 (36%) August-lambing 2-year-old ewes showed clinical signs of facial eczema and were removed from the trial in May 1989. Fewer 3-year-old ewes showed signs of clinical facial eczema (17 (10%) June v. 6 (7%) August) and were also removed from the trial. The difference between the two ages can probably be attributed to their grazing different pastures within the farm. The June-lambing ewes, already pregnant during the facial eczema risk period, grazed to lower residual dry matters and were therefore more likely to ingest *Pithomyces chartarum* spores than the August-lambing ewes which grazed to higher residual dry matters. The August-lambing ewes were being fed to achieve increased liveweight gains over the mating period which coincided with the facial eczema risk period. There were no differences between the crosses in the incidence of clinical facial eczema.

Unfasted ewe liveweights were recorded pre- and post-mating, mid-pregnancy, pre-lambing, weaning and one month prior to the next mating. Liveweight immediately post-lambing was calculated by taking liveweight prior to lambing and subtracting the total liveweight of lambs born together with a constant allowance for the weight of fluids and placenta of 40% of the total birth weight of lambs (Rattray *et al.* 1974; Robinson *et al.* 1977). Post-shearing liveweights were calculated by subtracting the greasy fleece weight from the liveweight taken just prior to shearing.

Yearly greasy fleece weights were recorded immediately after shearing (belly wool included) on an electronic weighing system (Tru-Test Distributors Ltd, Auckland).

Lambs were weighed at birth, tagged and identified to their dam. Lamb liveweights were recorded at weaning when the average age of lambs was 90 days. The lambs born (2% of all lambs) and reared (< 1%) as triplets were classified as multiples together with the lambs that were born and reared as twins. Ewes were classified to litter size groups for pre-lambing traits on the basis of number of lambs born while for post-lambing traits litter size was based on the number of lambs reared. Ewes that produced twin lambs but only reared one of the pair were classified as rearing a single lamb. There were fewer than 6% of lambs and 7% of the ewes in this classification.

Statistical Methods

Ewe liveweight change and fleece weights were analysed using a univariate analysis of variance to test the effects of policy, cross, year and their interactions. As each ewe age was not represented in every year (no 3-year-olds in 1987 and no 2-year-olds in 1990) the 2-year-old and 3-year-old ewe and lamb data were analysed separately. Results are therefore presented independently for 2-year-old and 3-year-old ewes. Actual ewe liveweight at each weighing was analysed within lambing policy as comparisons at a fixed time across policies were confounded with ewe physiological state. Univariate analysis of variance was considered appropriate because of the need to identify times of the year at which significant weight differences between crosses occurred within lambing policies. However, results of these analysis must be interpreted with caution in recognition of the fact that sequential samples represented repeated measurements of each trait on the same animal (Gill & Hafs 1971).

The model used to analyse ewe liveweight change and fleece weight was:

$$Y_{ijkl} = \mu + P_i + C_j + T_k + PC_{ij} + PT_{ik} + CT_{jk} + PCT_{ijk} + e_{ijkl} \qquad \textit{(Model 3.1)}$$

where

Y_{ijkl} = an observation on the lth ewe of the ith policy, the jth cross and the kth year.

μ = the general mean.

P_i = the fixed effect of the ith breeding policy (i=1 or 2)

C_j = the fixed effect of the jth cross (j=1....3)

T_k = the random effect of the kth year (k=1....3)

PC_{ij} = the interaction of the ith policy with the jth cross.

PT_{ik} = the interaction of the ith policy with the kth year.

CT_{jk} = the interaction of the jth cross with the kth year.

PCT_{ijk} = the interaction of the ith policy with the jth cross and kth year.

e_{ijkl} = the random residual associated with an observation on the lth ewe of the ith policy, the jth cross and in the kth year.

Differences between group means were tested according to pre-planned comparisons using t-tests (Snedecor & Cochran 1967). Data were expressed in terms of means (± SEM). Interaction terms that were not significant (P>0.05) were deleted from the model. Litter size and lamb sex and their appropriate interaction terms were added to Model 3.1 for the analyses of lamb birth and weaning weights. Lamb birth weight was also fitted as a covariate in the weaning weight model.

Proportions of ewes lambing and rearing a lamb relative to those ewes mated, together with the proportion of ewes lambing and rearing singles v. multiples, were analysed as binomial traits using the SAS procedure for categorical data modelling (CATMOD). CATMOD uses maximum likelihood estimation of parameters for log linear models and the analyses of generalised logits. The model was the same as Model 3.1. Differences between group means were tested according to pre-planned comparisons using the Chi-Square statistic (SAS 1985).

RESULTS

Two-Year-Old Ewe and Lamb Data

Ewe Liveweight

The liveweight profiles for the three ewe crosses within each breeding policy are shown in Fig. 3.1. The interaction of cross with year was non-significant. Hence the liveweight profiles are averaged across years.

Suffolk x BR ewes were the heaviest ewes throughout the year irrespective of breeding policy. Differences in liveweight between BR and PBR ewes varied according to breeding policy. The August-lambing PBR ewes were significantly ($P<0.001$) heavier than BR ewes over mating and pregnancy, while there was no difference between June-lambing BR and PBR ewes over this period. June-lambing BR ewes were significantly ($P<0.001$) heavier throughout the lactation period than PBR ewes, but there was no difference between these two crosses in the August-lambing ewes.

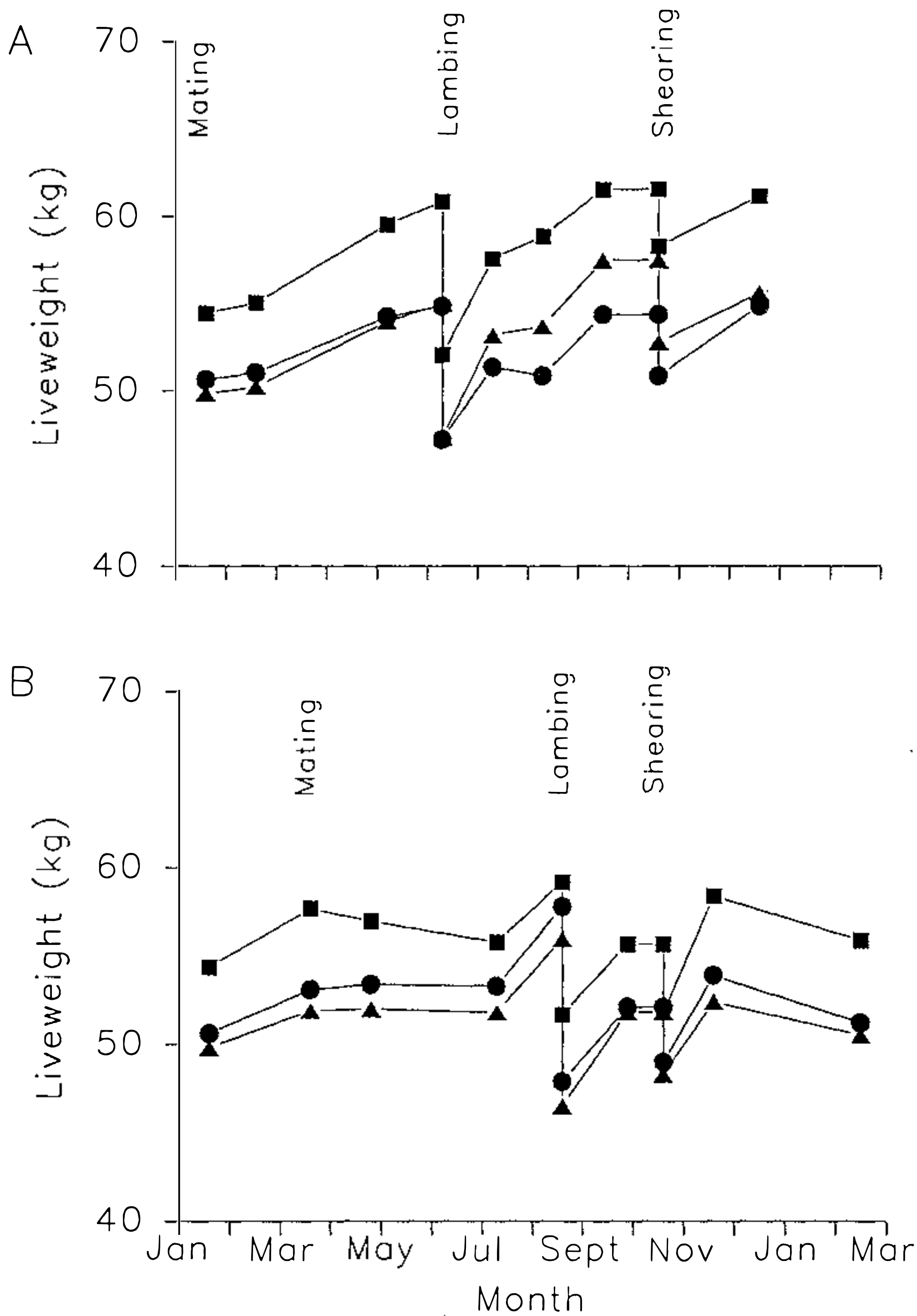

Fig. 3.1 **Mean liveweights of Border Leicester x Romney (BR) (▲), Poll Dorset x BR (PBR) (●) and Suffolk x BR (SBR) (■) June -(A) and August -(B) lambing 2-year-old ewes. Pooled SEM at each time were 0.3 to 0.6 kg.**

Policy effects on annual ewe liveweight change were not consistent between years as reflected in a significant (P<0.05) policy x year interaction (Table 3.2). The June-lambing 2-year-old ewes always gained more (or lost less) weight over a 12 month period than August-lambing 2-year-olds but the magnitude of this superiority varied by year.

June-lambing SBR and BR ewes gained more liveweight (P<0.05) than corresponding PBR ewes throughout the 12 month period (Table 3.2). However, there was no difference between the three ewe crosses for 12 month liveweight change in the August-lambing ewes. There was thus a significant (P<0.05) policy x cross interaction.

Table 3.2 Effect of breeding policy, year and cross on annual liveweight change (LWC) of 2-year-old ewes (Mean±SEM).

	June		August	
	No.	**LWC (kg)**	**No.**	**LWC (kg)**
Year				
1987	260	12.4 ± 0.3^{e}	233	0.9 ± 0.3^{c}
1988	173	-3.2 ± 0.4^{b}	156	-8.5 ± 0.4^{a}
1989	47	6.9 ± 0.7^{d}	73	2.2 ± 0.6^{c}
Cross[1]				
BR	151	5.6 ± 0.5^{c}	143	-1.5 ± 0.5^{a}
PBR	172	4.1 ± 0.4^{b}	163	-2.6 ± 0.4^{a}
SBR	157	6.2 ± 0.5^{c}	156	-1.5 ± 0.4^{a}
Overall Mean	480	5.3 ± 0.3^{b}	462	-1.8 ± 0.2^{a}

[1] BR = Border Leicester x Romney, PBR = Poll Dorset x BR, SBR = Suffolk x BR.
[abcde] Means within main effects having superscripts with letters in common are not significantly different (P>0.05).

As expected twin-bearing and rearing ewes gained significantly ($P<0.001$) less liveweight than single-bearing/rearing or barren ewes over the 12 month period (0.1 v. 3.7 v. 5.9 kg for twin, single and barren ewes, respectively).

June-lambing ewes gained more weight than August-lambing ewes over mating and over mid-pregnancy in two out of three years (policy x year interaction significant at $P<0.001$, Table 3.3). August-lambing ewes gained significantly more weight in late pregnancy compared with June-lambers (Table 3.4) but the magnitude of the difference varied between years. A significant ($P<0.001$) policy x year interaction for liveweight change from lambing to weaning reflected the fact that June-lambing ewes had significantly ($P<0.001$) higher liveweight gains in 1988 and 1989 while in 1987 the August-lambing ewes gained more liveweight than the June-lambing ewes (Table 3.4).

There was no effect of ewe cross on liveweight change over mating (Table 3.3). During mid-pregnancy August-lambing SBR ewes had a greater liveweight loss than BR or PBR ewes whereas there was no difference between the three crosses in the June-lambing ewes (policy x cross interaction, $P<0.01$).

The effects of policy and cross on liveweight change during late pregnancy were also non-additive (interaction $P<0.01$). Among the August-lambing group, SBR ewes gained more weight than BR ewes whereas, among the June-lambing group, the highest weight gain was in the BR group. During the lactation period, PBR ewes had the lowest liveweight gain of all the crosses while SBR ewes had the highest liveweight gains and BR ewes were intermediate under both policies (Table 3.4).

Ewe pregnancy status was not related to liveweight gain over mating but, as expected, twin-bearing ewes gained significantly ($P<0.001$) more liveweight in late pregnancy than single-bearing ewes (3.3 ± 0.2 v. 2.6 ± 0.1 kg). Ewes rearing twin lambs gained 5.9 ± 0.4 kg over lactation compared to 6.8 ± 0.3 kg for ewes rearing singles ($P<0.10$).

Table 3.3 **Effect of breeding policy, year and cross on pre- to post-mating and mid-pregnancy liveweight change (LWC) of 2-year-old ewes (Mean ± SEM).**

	June		August	
	No.	LWC (kg)	No.	LWC (kg)
Pre- to Post-Mating				
Year				
1987	275	2.7±0.2[d]	256	-0.1±0.2[b]
1988	177	-1.9±0.2[a]	181	0.1±0.2[b]
1989	123	0.7±0.3[c]	139	0.3±0.2[bc]
Cross[1]				
BR	186	0.6±0.2	179	0.3±0.2
PBR	204	0.4±0.2	202	0.3±0.2
SBR	185	0.5±0.2	195	-0.4±0.2
Overall Mean	575	0.5±0.1[b]	576	0.1±0.1[a]
Mid-Pregnancy				
Year				
1987	222	4.4±0.2[e]	248	-1.4±0.2[b]
1988	150	3.6±0.2[d]	156	-3.3±0.2[a]
1989	40	3.1±0.4[cd]	56	2.2±0.4[c]
Cross[1]				
BR	123	3.6±0.3[c]	152	-0.4±0.2[b]
PBR	147	3.8±0.3[c]	158	-0.7±0.2[b]
SBR	142	3.8±0.3[c]	150	-1.4±0.3[a]
Overall Mean	412	3.7±0.2[b]	460	-0.8±0.1[a]

[1] BR = Border Leicester x Romney, PBR = Poll Dorset x BR, SBR = Suffolk x BR.

[abcd] Means within main effects having superscripts with letter in common are not significantly different ($P > 0.05$).

Table 3.4 **Effect of breeding policy, year and cross on late pregnancy and post-lambing to weaning liveweight change (LWC) of 2-year-old ewes (Mean ± SEM).**

	June		August	
	No.	**LWC (kg)**	**No.**	**LWC (kg)**
Late-Pregnancy				
Year				
1987	194	3.4 ± 0.3^{c}	211	6.5 ± 0.3^{d}
1988	107	-1.4 ± 0.3^{a}	150	3.0 ± 0.3^{c}
1989	36	0.4 ± 0.5^{b}	48	3.3 ± 0.4^{c}
Cross[1]				
BR	92	1.5 ± 0.4^{b}	129	3.8 ± 0.3^{c}
PBR	127	0.3 ± 0.3^{a}	139	4.3 ± 0.3^{cd}
SBR	118	0.6 ± 0.3^{a}	142	4.6 ± 0.3^{d}
Overall Mean	337	0.8 ± 0.2^{a}	409	4.2 ± 0.2^{b}
Post-Lambing to Weaning				
Year				
1987	171	7.7 ± 0.5^{b}	194	9.4 ± 0.4^{c}
1988	91	7.9 ± 0.6^{b}	122	2.8 ± 0.6^{a}
1989	21	10.3 ± 1.1^{c}	30	6.4 ± 0.9^{b}
Cross[1]				
BR	75	8.9 ± 0.6^{cd}	106	6.2 ± 0.7^{a}
PBR	110	7.1 ± 0.6^{b}	120	4.9 ± 0.6^{ab}
SBR	98	9.9 ± 0.8^{d}	120	7.5 ± 0.6^{bc}
Overall Mean	283	8.6 ± 0.5^{b}	346	6.2 ± 0.5^{a}

[1] BR = Border Leicester x Romney, PBR = Poll Dorset x BR, SBR = Suffolk x BR.

[abcd] Means within main effects having superscripts with letters in common are not significantly different ($P > 0.05$).

Wool Production

June-lambing ewes had significantly ($P<0.001$) higher greasy fleece weights than August-lambing ewes in 2 out of the 3 years, reflecting a significant ($P<0.05$) policy x year interaction.

Table 3.5 Effects of breeding policy, year and cross on greasy fleece weight of 2-year-old ewes (Mean ± SEM).

	June		August	
	No.	Fleece Weight (kg)	No.	Fleece Weight (kg)
Year				
1987	172	4.1 ± 0.1^{c}	211	3.6 ± 0.1^{b}
1988	24	3.2 ± 0.1^{a}	80	3.2 ± 0.1^{a}
1989	29	4.7 ± 0.1^{d}	36	3.6 ± 0.1^{b}
Cross[1]				
BR	74	4.8 ± 0.1^{e}	108	4.1 ± 0.1^{d}
PBR	83	3.8 ± 0.1^{c}	107	3.4 ± 0.1^{b}
SBR	68	3.5 ± 0.1^{b}	112	3.1 ± 0.1^{a}
Overall Mean	225	4.0 ± 0.1^{b}	327	3.5 ± 0.1^{a}

[1] BR = Border Leicester x Romney, PBR = Poll Dorset x BR, SBR = Suffolk x BR.
[abcde] Means within main effects having superscripts with letters in common are not significantly different ($P>0.05$).

Border Leicester x Romney ewes produced significantly ($P<0.001$) more wool than PBR ewes which in turn produced more than the SBR ewes in both policies. A significant ($P<0.05$) policy x cross interaction reflected the greater wool production advantage of BR ewes over PBR and SBR ewes in the June-lambing policy compared to the August-lambing policy. There was no influence of litter size on wool production nor any interaction of litter size with year, policy or cross.

Ewe Reproductive Performance

A lower proportion of ewes lambed in June than in August in 1987 while in 1988 a lower proportion lambed in August (Table 3.6). During 1989, however there was no effect of policy on the proportion of ewes lambing reflecting a significant ($P < 0.05$) policy x year interaction. There was no effect of ewe cross on the proportion of ewes lambing or rearing a lamb. There were significantly ($P < 0.001$) fewer ewes rearing lambs to weaning in 1989 than in 1987 or 1988. August-lambing ewes had a higher proportion of multiple births ($P < 0.01$) than June-lambing ewes across all years (Table 3.7). They also had a higher proportion of ewes rearing multiples (of those ewes that had lambed) compared to June-lambing ewes. Year and ewe cross had no significant effect on the proportion of ewes having multiple births or rearing multiples.

Lamb Liveweights

Lambs born to the August-lambing ewes had significantly ($P < 0.001$) higher birth and weaning weights than lambs born to June-lambing ewes (Table 3.8). Differences in mean birth weight between lambs born to June- and August-lambing ewes varied from 0.5 kg in 1987 to 1.1 kg in 1989. However, the difference in weaning weight between policies was only significant ($P < 0.01$) in 1987 reflecting a significant policy x year interaction, ($P < 0.01$).

Birth weight of lambs was not significantly influenced by cross of the dam. However, in both June- and August-lambing policies, PBR ewes weaned heavier lambs than BR ewes while there was no difference in lamb weaning weight between lambs born to SBR or BR ewes.

Male lambs were significantly ($P < 0.001$) heavier at birth (4.2 ± 0.1 v. 4.0 ± 0.1 kg) and at weaning (26.2 ± 0.2 v. 24.2 ± 0.2 kg) than female lambs. Single-born lambs were heavier at birth (4.5 ± 0.1 v. 3.6 ± 0.1, $P < 0.01$) than twin-born lambs while single-reared lambs had higher weaning weights (27.6 ± 0.1 v. 22.8 ± 0.3 kg, $P < 0.01$) than twin-reared lambs.

Table 3.6 **Effect of breeding policy, year and cross on the proportion of 2-year-old ewes lambing or rearing a lamb to weaning.**

	June		August	
	No.	Proportion (%)	No.	Proportion (%)
Ewes Lambing				
Year				
1987	279	1.62[2]±0.16[b](84)[3]	264	2.21±0.21[a](90)
1988	186	1.39±0.18[b](80)	208	0.79±0.15[c](69)
1989	135	-0.90±0.19[d](29)	204	-1.35±0.17[d](21)
Cross[1]				
BR	197	0.56±0.15(64)	217	0.46±0.14(61)
PBR	211	1.14±0.16(76)	228	0.45±0.14(61)
SBR	192	0.84±0.16(70)	231	0.65±0.14(65)
Overall Mean	600	0.85±0.09(70)	676	0.51±0.08(63)
Ewes Rearing Lambs				
Year				
1987	279	1.04±0.14[a](74)	264	1.26±0.15[a](78)
1988	186	0.69±0.16[a](67)	208	0.59±0.14[a](64)
1989	135	-1.25±0.21[b](21)	204	-1.51±0.18[b](18)
Cross[1]				
BR	197	0.11±0.14(53)	217	0.23±0.14(56)
PBR	211	0.62±0.14(65)	228	0.23±0.13(56)
SBR	192	0.49±0.15(62)	231	0.23±0.13(56)
Overall Mean	600	0.41±0.08(60)	676	0.23±0.08(56)

1 BR = Border Leicester x Romney, PBR = Poll Dorset x BR, SBR = Suffolk x BR.
2 Logit-transformed.
3 Back-transformed (%).
abcd Means within main effects having superscripts with letters in common are not significantly different (P>0.05).

Table 3.7 **Effect of breeding policy, year and cross on the proportion of 2-year-old ewes with multiple births and rearing multiples.**

	June		August	
	No.	Proportion (%)	No.	Proportion (%)
Multiple Births				
Year				
1987	233	-1.15±0.15[2](24)[3]	238	-0.46±0.13(39)
1988	149	-1.04±0.19(26)	143	-0.15±0.17(46)
1989	39	-1.20±0.38(23)	43	-0.42±0.31(40)
Cross[1]				
BR	127	-1.13±0.20(24)	134	-0.68±0.18(34)
PBR	160	-1.13±0.18(24)	139	-0.30±0.17(42)
SBR	134	-1.08±0.20(25)	151	-0.12±0.16(47)
Overall Mean	421	-1.11±0.11[b](25)	424	-0.35±0.10[a](41)
Rearing Multiples				
Year				
1987	206	-1.36±0.17(20)	206	-0.80±0.15(31)
1988	124	-1.43±0.23(19)	134	-0.75±0.18(32)
1989	30	-1.87±0.54(13)	37	-0.50±0.34(38)
Cross[1]				
BR	104	-1.50±0.25(18)	121	-1.15±0.21(24)
PBR	137	-1.27±0.21(22)	127	-0.74±0.19(32)
SBR	119	-1.54±0.24(18)	129	-0.42±0.18(40)
Overall Mean	360	-1.41±0.13[b](19)	377	-0.75±0.11[a](32)

1 BR = Border Leicester x Romney, PBR = Poll Dorset x BR, SBR = Suffolk x BR.
2 Logit-transformed.
3 Back-transformed (%).
ab Means within main effects having superscripts with letters in common are not significantly different (P>0.05).

Table 3.8 **Effect of breeding policy, year and damcross on the birth weight and weaning weight of lambs born to 2-year-old ewes (Mean ± SEM).**

	June		August	
	No.	**Weight (kg)**	**No.**	**Weight (kg)**
Birth Weight				
Year				
1987	248	3.9 ± 0.1^{b}	346	4.4 ± 0.1^{c}
1988	184	4.2 ± 0.1^{c}	206	4.8 ± 0.1^{d}
1989	42	3.1 ± 0.2^{a}	57	4.2 ± 0.1^{c}
Damcross[1]				
BR	131	3.8 ± 0.1	182	4.5 ± 0.1
PBR	188	3.7 ± 0.1	202	4.5 ± 0.1
SBR	155	3.8 ± 0.1	225	4.4 ± 0.1
Overall Mean	474	3.8 ± 0.1^{a}	609	4.4 ± 0.1^{b}
Weaning Weight				
Year				
1987	210	26.8 ± 0.3^{c}	282	28.2 ± 0.2^{d}
1988	143	23.5 ± 0.3^{a}	174	23.6 ± 0.3^{a}
1989	31	25.0 ± 0.7^{b}	48	26.0 ± 0.5^{bc}
Damcross[1]				
BR	101	24.1 ± 0.4^{a}	154	25.4 ± 0.4^{a}
PBR	155	26.1 ± 0.4^{b}	172	26.4 ± 0.3^{b}
SBR	128	25.1 ± 0.4^{a}	178	26.0 ± 0.3^{ab}
Overall Mean	384	25.1 ± 0.3^{a}	504	25.9 ± 0.2^{b}

[1] BR = Border Leicester x Romney, PBR = Poll Dorset x BR, SBR = Suffolk x BR.

[abcd] Means within main effects having superscripts with letters in common are not significantly different ($P > 0.05$).

Three-Year-Old Ewe and Lamb Data

Ewe Liveweight

Liveweight profiles of the three ewe crosses for each lambing policy treatment are shown in Figure 3.2. The SBR ewes were heavier than BR or PBR ewes on all occasions in both lambing policy treatments. The June-lambing BR ewes were heavier than June-lambing PBR ewes from docking (25 June) until shearing (20 October) but after this time there was no difference between these two crosses. August-lambing BR ewes had a similar liveweight profile to August-lambing PBR ewes.

There were significant ($P<0.05$) policy x year and policy x cross interactions for total liveweight change over the 12 month period (Table 3.9). June- lambing ewes gained significantly ($P<0.05$) more (or lost less) liveweight than August-lambing ewes in 1988 and 1989 while in 1990 there was no difference in liveweight change over the year.

June-lambing SBR ewes gained more liveweight over the 12 month period than June-lambing BR and PBR ewes. Among the August-lambing group, PBR ewes lost liveweight (0.8 kg) while BR and SBR ewes gained a similar amount of liveweight (Table 3.9). Over all years and crosses, June-lambing ewes gained more liveweight than August-lambing ewes.

Litter size influenced 12-monthly ewe liveweight change with single bearing/rearing ewes gaining weight (1.6 ± 0.3 kg) while twin bearing/rearing ewes lost weight (-1.3 ± 0.5 kg). The difference between the two groups was greater in June-lambing ewes than in August-lambing ewes (policy x litter size interaction, $P<0.05$).

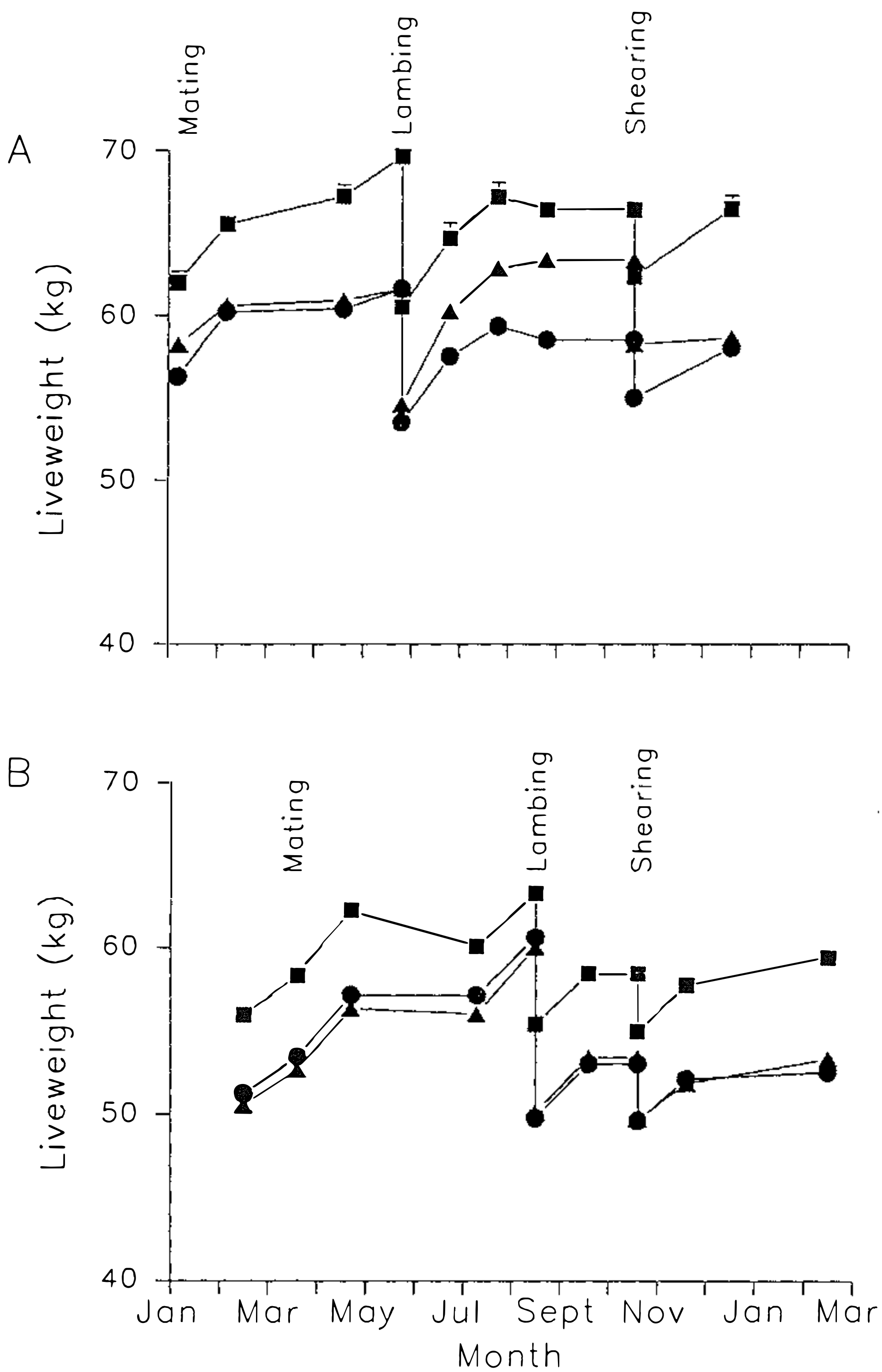

Fig. 3.2 **Mean liveweights of Border Leicester x Romney (BR) (▲), Poll Dorset x BR (PBR) (●) and Suffolk x BR (SBR) (■) June -(A) and August -(B) lambing 3-year-old ewes. Pooled SEM at each time were 0.4 to 0.9 kg**

Table 3.9 Effect of breeding policy, year and cross on annual liveweight change (LWC) of 3-year-old ewes (Mean ± SEM).

	June		August	
	No.	LWC (kg)	No.	LWC (kg)
Year				
1988	179	-1.3 ± 0.5^b	229	-4.1 ± 0.4^a
1989	73	6.9 ± 0.7^d	142	2.2 ± 0.5^c
1990	34	1.9 ± 1.0^c	55	2.8 ± 0.8^c
Cross[1]				
BR	67	1.4 ± 0.8^b	133	0.8 ± 0.6^b
PBR	122	1.7 ± 0.6^b	152	-0.8 ± 0.5^a
SBR	97	4.4 ± 0.7^c	141	0.9 ± 0.6^b
Overall Mean	286	2.5 ± 0.5^b	426	0.3 ± 0.3^a

[1] BR = Border Leicester x Romney, PBR = Poll Dorset x BR, SBR = Suffolk x BR.
[abcd] Means within main effects having superscripts with letters in common are not significantly different (P > 0.05).

Throughout the mating period the June-lambing ewes had greater liveweight gains in 1988 and 1989 but in 1990 the August-lambing ewes gained the most liveweight over mating (Table 3.10). This reflected a significant (P<0.05) policy x year interaction. Ewe cross had no effect on liveweight change over mating.

June-lambing pregnant ewes gained weight over the mid-pregnancy period in 1988 and 1990 while the August-lambing ewes lost liveweight over this period. In 1989 this pattern was reversed as August-lambing pregnant ewes gained liveweight while their June-lambing counterparts lost liveweight. As a result, the policy x year interaction was significant (P<0.05) for liveweight change during mid-pregnancy (Table 3.10). There was a significant (P<0.05) policy x cross interaction for

Table 3.10 **Effect of breeding policy, year and cross on pre- to post-mating and mid-pregnancy liveweight change (LWC) of 3-year-old ewes (Mean±SEM).**

	June		August	
	No.	LWC (kg)	No.	LWC (kg)
Pre to Post-Mating				
Year				
1988	200	4.2 ± 0.2^{d}	252	3.6 ± 0.2^{c}
1989	91	3.1 ± 0.3^{bc}	171	1.0 ± 0.2^{a}
1990	47	2.3 ± 0.4^{b}	91	6.3 ± 0.3^{e}
Cross[1]				
BR	83	2.6±0.3	161	3.7±0.2
PBR	139	3.4±0.4	190	3.6±0.2
SBR	116	3.5±0.3	163	3.6±0.2
Overall Mean	338	3.2±0.2	514	3.6±0.1
Mid-pregnancy				
Year				
1988	167	1.5 ± 0.3^{d}	210	-3.2 ± 0.2^{b}
1989	75	-1.4 ± 0.4^{c}	126	4.4 ± 0.3^{e}
1990	43	1.6 ± 0.4^{d}	56	-4.1 ± 0.4^{a}
Cross[1]				
BR	62	0.1 ± 0.4^{bc}	119	-0.7 ± 0.3^{b}
PBR	122	0.6 ± 0.3^{c}	135	-0.6 ± 0.3^{b}
SBR	101	1.0 ± 0.3^{c}	138	-1.5 ± 0.3^{a}
Overall Mean	285	0.6 ± 0.2^{b}	392	-1.0 ± 0.2^{a}

[1] BR = Border Leicester x Romney, PBR = Poll Dorset x BR, SBR = Suffolk x BR.

[abcde] Means within main effects having superscripts with letters in common are not significantly different ($P > 0.05$).

liveweight change over mid-pregnancy. No differences between the crosses existed for liveweight change in the June-lambing ewes while in the August-lambers SBR ewes lost significantly ($P<0.05$) more liveweight over mid-pregnancy than either BR or PBR ewes.

Litter size had no effect on liveweight gain over mating while during the mid-pregnancy period twin-bearing ewes had significantly ($P<0.001$) greater liveweight gains than single-bearing ewes, which actually lost weight (1.1 ± 0.2 v. -0.6 ± 0.2 kg for twin- and single-bearing ewes, respectively).

August-lambing ewes gained significantly ($P<0.001$) more liveweight over late pregnancy in 1988 and 1990 than June-lambing ewes (Table 3.11). However this was not the case in 1989 when the order was reversed (policy x year interaction, $P<0.001$). Ewe cross had no effect on liveweight change over late pregnancy in June-lambing ewes while August-lambing BR ewes gained more liveweight over late-pregnancy than PBR ewes. There was no difference between PBR and SBR or SBR and BR for late-pregnancy liveweight change (significant policy x cross interaction, $P<0.01$).

June-lambing ewes gained significantly ($P<0.05$) more liveweight over lactation than August-lambing ewes in 1988 and 1990 while in 1989 there was no difference between these two groups.

A significant ($P<0.01$) policy x cross interaction reflected the fact that June-lambing BR ewes gained more liveweight during lactation than SBR and PBR ewes, but there were no significant difference in liveweight gain during lactation for the different ewe crosses lambing in August.

Ewes bearing twin lambs gained significantly ($P<0.01$) more liveweight over late pregnancy than ewes bearing single lambs (3.0 ± 0.2 v. 2.4 ± 0.1 kg). During lactation ewes that reared a single lamb gained significantly ($P<0.05$) more liveweight than ewes rearing twin lambs (4.7 ± 0.3 v. 3.5 ± 0.4 kg).

Table 3.11 **Effect of breeding policy, year and cross on late pregnancy and post-lambing to weaning liveweight change (LWC) of 3-year-old ewes (Mean±SEM).**

	June		August	
	No.	LWC (kg)	No.	LWC (kg)
Late-Pregnancy				
Year				
1988	154	-0.6 ± 0.2^{a}	203	1.1 ± 0.2^{b}
1989	71	5.5 ± 0.3^{d}	118	2.8 ± 0.2^{c}
1990	36	-1.3 ± 0.4^{a}	56	6.0 ± 0.3^{d}
Cross[1]				
BR	58	1.1 ± 0.3^{a}	114	3.6 ± 0.3^{c}
PBR	111	1.4 ± 0.4^{a}	127	2.9 ± 0.2^{b}
SBR	92	1.1 ± 0.3^{a}	136	3.4 ± 0.3^{bc}
Overall Mean	261	1.2 ± 0.2^{a}	377	3.3 ± 0.2^{b}
Post-Lambing to Weaning				
Year				
1988	135	6.8 ± 0.6^{bc}	171	0.3 ± 0.5^{a}
1989	53	6.7 ± 0.8^{bc}	107	5.1 ± 0.6^{b}
1990	31	7.8 ± 1.0^{c}	42	1.1 ± 0.9^{a}
Cross[1]				
BR	47	9.1 ± 0.7^{c}	88	1.8 ± 0.7^{a}
PBR	93	5.5 ± 0.9^{b}	109	1.7 ± 0.6^{a}
SBR	79	6.8 ± 0.8^{b}	123	2.9 ± 0.6^{a}
Overall Mean	219	7.1 ± 0.6^{b}	320	2.1 ± 0.5^{a}

[1] BR = Border Leicester x Romney, PBR = Poll Dorset x BR, SBR = Suffolk x BR.

[abcde] Means within main effects having superscripts with letters in common are not significantly different ($P>0.05$).

Wool Production

June-lambing ewes produced significantly ($P<0.001$) higher fleece weights than August-lambing ewes (4.1 ± 0.1 v. 3.6 ± 0.1 kg, Table 3.12). There was, however, a significant ($P<0.001$) policy x year interaction with the magnitude of the difference in wool production between June- and August-lambers varying between years (range 0.2 to 0.8 kg).

Border Leicester x Romney 3-year-old ewes had higher fleece weights than PBR ewes which in turn had higher fleece weights than SBR ewes. The ranking of the different ewe crosses was consistent across years and breeding policies. There was no difference in fleece weight between ewes rearing single or twin lambs.

Table 3.12 Effect of breeding policy, year and cross on greasy fleece weight of 3-year-old ewes (Mean ± SEM).

	June		August	
	No.	Fleece Weight (kg)	No.	Fleece Weight (kg)
Year				
1988	129	3.8 ± 0.1^{b}	191	3.6 ± 0.1^{a}
1989	65	4.3 ± 0.1^{c}	109	3.5 ± 0.1^{a}
1990	33	4.1 ± 0.1^{c}	53	3.7 ± 0.1^{ab}
Cross[1]				
BR	62	4.7 ± 0.1^{c}	53	4.2 ± 0.1^{f}
PBR	126	4.0 ± 0.1^{b}	89	3.4 ± 0.1^{e}
SBR	41	3.5 ± 0.1^{a}	22	3.1 ± 0.1^{d}
Overall Mean	227	4.1 ± 0.1^{b}	353	3.6 ± 0.1^{a}

[1] BR = Border Leicester x Romney, PBR = Poll Dorset x BR, SBR = Suffolk x BR.

[abcdef] Means within main effects having superscripts with letters in common are not significantly different ($P>0.05$).

Ewe Reproductive Performance

A significantly ($P < 0.05$) higher proportion of June-lambing ewes which were mated subsequently lambed compared with those ewes mated in August (Table 3.13). However, there was no difference between the June- or August-lambing ewes in the proportion of ewes mated which reared a lamb.

Year effects were significant ($P<0.001$) for the proportion of ewes lambing and rearing a lamb but the year differences were consistent across breeding policy.

The effect of ewe cross on the proportion of ewes lambing was non-significant. However marginally fewer BR ewes reared a lamb to weaning than PBR or SBR ewes ($P<0.10$, Table 3.13).

August-lambing ewes had a significantly higher ($P<0.01$) proportion of multiple births and they reared a higher proportion of multiples compared to June-lambing ewes (Table 3.14). There was no difference between years or ewe crosses in the proportion of multiple births or in the proportion of ewes rearing multiples.

Table 3.13 Effect of breeding policy, year and cross on the proportion of 3-year-old ewes lambing or rearing a lamb to weaning.

	June		August	
	No.	Proportion (%)	No.	Proportion (%)
Ewes Lambing				
Year				
1988	212	$1.17^{2} \pm 0.16^{a}(76)^{3}$	268	$1.15 \pm 0.14^{a}(76)$
1989	104	$0.72 \pm 0.21^{a}(67)$	231	$0.18 \pm 0.13^{b}(55)$
1990	50	$1.15 \pm 0.33^{a}(76)$	93	$0.50 \pm 0.21^{b}(62)$
Cross[1]				
BR	92	0.67±0.22(66)	193	0.68±0.14(59)
PBR	152	1.13±0.19(76)	208	0.68±0.14(66)
SBR	122	1.21±0.22(77)	191	0.90±0.16(71)
Overall Mean	366	$1.03 \pm 0.12^{a}(74)$	592	$0.64 \pm 0.09^{b}(66)$
Ewes Rearing Lambs				
Year				
1988	212	$0.77 \pm 0.15^{a}(68)$	268	$0.84 \pm 0.13^{a}(70)$
1989	104	$0.39 \pm 0.20^{ab}(60)$	231	$0.08 \pm 0.13^{b}(52)$
1990	50	$0.84 \pm 0.30^{a}(70)$	93	$0.19 \pm 0.21^{b}(55)$
Cross[1]				
BR	92	0.31±0.21(59)	193	0.15±0.14(54)
PBR	152	0.80±0.18(69)	208	0.39±0.15(59)
SBR	122	0.79±0.20(68)	191	0.76±0.15(68)
Overall Mean	366	0.67±0.11(66)	592	0.42±0.08(61)

1 BR = Border Leicester x Romney, PBR = Poll Dorset x BR, SBR = Suffolk x BR.
2 Logit-transformed.
3 Back-transformed (%).
ab Means within main effects having superscripts with letters in common are not significantly different (P>0.05).

Table 3.14 **Effect of breeding policy, year and cross on the proportion of 3-year-old ewes with multiple births or rearing multiples.**

	June		August	
	No.	Proportion (%)	No.	Proportion (%)
Multiple Births				
Year				
1988	163	-0.82[2]±0.17(31)[3]	204	-0.10±0.14(48)
1989	70	-1.22±0.28(23)	129	-0.30±0.18(43)
1990	38	-0.77±0.35(32)	58	-0.72±0.28(33)
Cross[1]				
BR	62	-1.23±0.31(23)	117	-0.54±0.19(37)
PBR	115	-0.83±0.20(30)	138	-0.29±0.17(43)
SBR	94	-0.81±0.22(31)	136	0.03±0.17(51)
Overall Mean	271	-0.91±0.13[b](29)	391	-0.25±0.10[a](44)
Rearing Multiples				
Year				
1988	145	-1.07±0.19(26)	186	-0.37±0.15(41)
1989	62	-1.65±0.35(16)	120	-0.48±0.19(38)
1990	35	-0.78±0.36(31)	51	-0.60±0.29(35)
Cross[1]				
BR	53	-1.58±0.19(26)	103	-0.79±0.21(31)
PBR	105	-0.96±0.22(28)	124	-0.29±0.18(43)
SBR	84	-1.16±0.26(24)	130	-0.31±0.17(42)
Overall Mean	242	-1.15±0.15[b](24)	357	-0.44±0.17[a](39)

1 BR = Border Leicester x Romney, PBR = Poll Dorset x BR, SBR = Suffolk x BR.
2 Logit-transformed.
3 Back-transformed (%).
ab Means within main effects having superscripts with letters in common are not significantly different (P>0.05).

Lamb Liveweights

A significant policy x year interaction for lamb birth weight reflected the fact that the magnitude of the difference in birth weight between June- and August-born lambs varied between years (Table 3.15). Lambs born to August-lambing ewes had significantly ($P<0.001$) higher birth weights than lambs born to June-lambing ewes. In 1989 there was a 1.0 kg difference in birth weights between June- and August-born lambs while the difference was 0.6 kg for both the 1988- and the 1990-born lambs.

Lambs born to June-lambing SBR ewes had significantly higher birth weights than lambs born to June-lambing BR or PBR ewes but there was no difference in birth weights of lambs born to each of three ewe crosses lambing in August (policy x cross interaction, $P<0.05$). Male lambs had higher birth weights than female lambs (4.5 ± 0.1 v. 4.0 ± 0.1 kg, $P<0.001$) while single-born lambs had higher birth weights than twin-born lambs (4.9 ± 0.1 v. 4.0 ± 0.1 kg, $P<0.001$).

Lambs reared by August-lambing ewes were heavier at weaning than lambs reared by June-lambing ewes (26.2 ± 0.2 v. 25.4 ± 0.3 kg).

There were no year effects on weaning weights of June-born lambs but weaning weights differed in each year for the August-born lambs, reflecting a significant ($P<0.001$) policy x year interaction for lamb weaning weight (Table 3.15).

The damcross of the lamb had no significant effect on lamb weaning weight. Male lambs weighed more than female lambs at weaning (26.1 ± 0.2 v. 25.1 ± 0.2 kg, $P<0.01$) as did single-reared lambs compared to twin-reared lambs (28.1 ± 0.2 v. 23.1 ± 0.1 kg, $P<0.001$).

Table 3.15 Effect of breeding policy, year and damcross on the birth weight and weaning weight of lambs born to 3-year-old ewes (Mean±SEM).

	June		August	
	No.	**Weight (kg)**	**No.**	**Weight (kg)**
Birth Weight				
Year				
1988	195	4.2±0.1[b]	274	4.8±0.1[c]
1989	87	3.9±0.1[a]	165	4.9±0.1[d]
1990	50	4.0±0.1[ab]	66	4.6±0.1[c]
Damcross[1]				
BR	67	4.0±0.1[a]	135	4.7±0.1[c]
PBR	143	3.9±0.1[a]	178	4.9±0.1[c]
SBR	122	4.3±0.1[b]	192	4.8±0.1[c]
Overall Mean	332	4.1±0.1[a]	505	4.8±0.1[b]
Weaning weight				
Year				
1988	168	25.1±0.3[a]	233	24.6±0.2[a]
1989	73	25.5±0.5[ab]	148	27.7±0.3[c]
1990	46	25.6±0.5[ab]	57	26:3±0.5[b]
Damcross				
BR	54	25.0±0.5	111	25.5±0.4
PBR	129	25.9±0.4	155	26.6±0.3
SBR	104	25.4±0.4	172	26.5±0.3
Overall Mean	287	25.4±0.3[a]	438	26.2±0.2[b]

[1] BR = Border Leicester x Romney, PBR = Poll Dorset x BR, SBR = Suffolk x BR.
[abcd] Means within main effects having superscripts with letters in common are not significantly different ($P > 0.05$).

DISCUSSION

The introduction of an out-of-season lambing policy is a major management change that requires careful planning and a willingness on the part of the farmer to make significant adjustments to existing farming practices. Even having a small proportion of a flock lambing early would affect all aspects of farm management. In practice a trade-off may be possible where some losses in performance are accepted for the spring lambing flock in order to yield greater benefits from the out-of-season lambing flock. An example is the allocation of a greater area of pasture to autumn-lambing ewes during their lactation (the winter) at the expense of pregnant spring-lambing ewes.

It is highly unlikely that a farmer would change the whole flock to an autumn lambing policy as this would make the system vulnerable to low winter pasture growth rates (Hawkins *et al.* 1989). The obvious strategy to counter low winter pasture growth rates is to lower stocking rates, but this would lead to an accumulation of large quantities of herbage during the late spring and summer periods with a resulting decline in pasture quality. It is for these reasons that a mix of autumn- and spring-lambing policies is likely to be the best strategy for farmers wanting to adopt out-of-season lambing. Several researchers have suggested a 30:70 spread between autumn and spring lambing as the best means of balancing pasture requirements and growth patterns, and maximising returns (Barlow 1986; McCall & Bywater 1987; Hawkins *et al.* 1989). An added benefit of such a mix is that any reduction in fertility or prolificacy found in out-of-season lambing ewes can potentially be reduced by exposing those ewes to rams for a second time during the natural breeding season.

Assuming that a mix of out-of-season and spring-lambing ewes is likely to be the best system, then it would clearly be advantageous to have the same ewe breed or cross in both, particularly if ewes are to move between policies. The three ewe crosses studied in this experiment were therefore evaluated across both policies to determine whether rankings changed between policies, years and ewe ages. Care must be taken in interpreting information from the two policies as the ewes from each policy differed in their physiological state at the same calendar date because of the three month difference in mating date. The two policies are being compared under situations which cannot be strictly controlled and may differ because of their exposure to different "environments" eg climate, photoperiod, feed allowance and feed quality.

To minimise nutritional differences between policies, pasture was allocated on the basis of pasture cover (kg DM/ha) with the same targets for each policy. In an effort to ensure that pasture quality was maintained at similar levels between policies, other classes of stock were introduced when average pasture cover increased above 1500 kg DM/ha. However, while this could be expected to reduce the confounding of policy and seasonal effects, it does not totally eliminate this problem.

Differences between 2- and 3-year-old ewes were generally consistent between the two policies and years. Therefore, for the purposes of this discussion, the two ewe ages will be considered as one group.

Lamb Production

Lambing Policy

Lambing policy did not influence the proportion of ewes lambing. This contrasts with research in Northland where a lower proportion of Dorset cross ewes joined with the ram in autumn lambed than those joined in spring (Andrewes 1983; McQueen & Reid 1988; Reid *et al.* 1988). The major difference between these experiments is the method of induction of out-of-season oestrus. The Northland researchers used natural selection to obtain ewes capable of showing oestrus out-of-season while in the present trial induction of out-of-season oestrus was via a combination of progesterone therapy and high ram to ewe ratios. This latter treatment may partially overcome the shorter duration of oestrus and lowered conception rates typically found in ewes in the non-breeding season, thereby increasing the proportion of ewes mating and lambing (Smith *et al.* 1988b; Knight *et al.* 1989b).

There were fewer multiple births recorded in the June-lambing ewes, although this group had higher liveweights and liveweight gains over the mating period than August-lambing ewes. A seasonal effect on ovulation rate frequently occurs during the breeding season, ovulation rate rising from that which is observed at first oestrus, plateauing, and then declining late in the breeding season (Kelly *et al.* 1976; Smith *et al.* 1987). Lowered ovulation rates, resulting in fewer multiple births, have been a feature of out-of-season breeding research programmes (Fitzgerald 1976; Smith *et al.* 1988b; Reid *et al.* 1988; Smith *et al.* 1989b). In a large trial involving 4700 ewes in 21 flocks in the Hawkes Bay, autumn-lambing ewes were found to have a multiple birth rate of 21% compared to 51% for spring-lambing ewes (Grace *et al.* 1989).

There is one report in the literature from North America where autumn-lambing ewes were observed to have a higher proportion of multiples (1.97 v. 1.74) than spring-lambing ewes (McNeal 1978). However, care must be taken in extrapolating data from trials such as that of McNeal (1978) where a gonadotrophic hormone has been used to induce the out-of-season lambing as it can artificially influence ovulation rate.

August-lambing ewes produced heavier lambs at birth than June-lambing ewes. This result is consistent with those from other studies (Quinlivan 1988; Reid *et al.* 1988; Peterson *et al.* 1990). However, McQueen (1986) recorded no difference in birth weight between autumn- and spring-born lambs. In a comprehensive all year-round lambing study, Cruickshank & Smith (1989) recorded birth weights of lambs born bi-monthly and found that lambs born in January and March were lighter than those born between May and November. There was a difference in birth weight between May- and September-born lambs (4.3±0.2 v. 4.8±0.1 kg) although this was statistically non-significant (Cruickshank & Smith 1989). Despite the difference between policies in lamb birth weight there was no significant difference in lamb losses between the two lambing policies in the present study. The proportions of "dead and missing" lambs born to June-lambing 2-year-old and 3-year-old ewes were 19% and 14% respectively. For August-lambing 2-year-old and 3-year-old ewes the loss rates were 14% and 13% respectively.

Lamb losses need to be viewed with caution as factors such as litter size and climatic conditions at lambing (Dalton *et al.* 1980) may influence differences in loss rates between spring and autumn. Some researchers have recorded higher losses in autumn-born than in spring-born lambs (McNeal 1978) while others have found that autumn-born lambs had lower death rates (Andrewes 1983; Reid *et al.* 1988; Thompson & Obst 1989). Thus no consistent pattern emerges with respect to the effects of policy on losses of young lambs.

The weaning weights of June-born lambs were lower than those of August-born lambs (range 0.2-2.2kg) in every year of the present trial. Other researchers have found that autumn-born lambs were lighter at weaning than their spring-born counterparts (Andrewes 1983; Reid *et al.* 1988; Cruickshank & Smith 1989; Peterson *et al.*1990). Factors such as higher intakes of better quality herbage, rising ambient temperature and photoperiod changes could all contribute to the increased growth rates of spring-born lambs. Peterson *et al.* (1990) recorded a lower milk production, and lower circulating prolactin levels, in autumn-lambing ewes compared to spring-lambing ewes. These authors suggested that the lowered milk yields of autumn-lambing ewes and hence low lamb growth rates may be caused by the lower circulating prolactin levels in the ewes rather than by dietary differences. Indirect support for this hypothesis comes from the present experiment where June- and August-lambing ewes were allocated similar pasture allowances. There are numerous data supporting an effect of changing daylength on lamb growth rates, lambs growing faster when exposed to increasing daylength (Forbes *et al.* 1975; Schanbacher & Crouse 1980; Ebling *et al.* 1989; Lincoln 1990). The mechanisms involved are not fully understood but are likely to be mediated via different patterns of melatonin secretion and associated increases in circulating growth hormone and/or prolactin levels during periods of increasing daylength (Barenton *et al.* 1988).

Policy x Year Interactions

The proportion of ewes lambing in each policy varied between years, reflecting a significant policy x year interaction. A higher proportion of January-mated ewes lambed in 1989 and 1990 compared with March-mated ewes but for 1987 there were more March-mated ewes lambing while in 1988 there was no difference between the two policies in the proportion of ewes lambing. Differences between policies for incidence of multiple births were consistent across years but the magnitude of differences between the birth weights of June- and August-born lambs varied between years (0.3-1.0 kg). Likewise there was a policy x year interaction for lamb weaning weight reflecting the fact that differences in weaning weight between policies varied from 0.1 kg to 2.2 kg across all years.

Ewe Cross

Differences between the three ewe crosses for the proportion of ewes lambing and the incidence of multiple births were small and non-significant. Poll Dorset x BR and SBR ewes produced marginally more lambs at weaning than BR ewes due both to a higher incidence of multiple births and a lower proportion of losses between birth and weaning.

No direct comparisons of the three crosses used in this trial were found in the literature. However, most comparisons involving Dorset x Romney and Border Leicester x Romney ewes have indicated very small differences in reproductive performance (Hight & Dalton 1974; Dalton 1975; Dalton 1976; Clarke & Meyer 1977; Carter & Cox 1982). No New Zealand data are available on the fertility or prolificacy levels of Suffolk x Whitefaced breeds of sheep. However this type of cross has achieved satisfactory levels of reproductive performance in Canada (Fahmy & Vesely 1977), the United States of America (Terrill 1982) and the United Kingdom (Read 1982).

Poll Dorset x BR ewes reared the heaviest lambs of the three crosses studied. Lambs reared by BR ewes were the lightest at weaning while SBR ewes reared lambs that were intermediate between those of the other two crosses. The rearing of heavier lambs by the PBR ewes was at the expense of a greater liveweight loss throughout lactation. Geenty *et al.* (1985) found that Dorset ewes produce 59% more milk than Romney ewes and it is probably some of this extra milk-producing ability, inherited from the Dorset, that accounts for the higher weaning weights of lambs reared by PBR ewes.

Policy x Cross Interactions

There were no policy x cross interactions for the proportions of ewes lambing or with multiple births.

Lambs born to June-lambing SBR ewes were heavier than lambs born to June-lambing PBR or BR ewes but this was not the case for August-born lambs. There was, however, no policy x cross interaction for lamb weaning weight indicating that PBR ewes weaned the heaviest lambs under both policies. Differences in lamb weaning weight between the three crosses were small and the lack of any significant policy x cross interactions indicates that the crosses perform similarly in both policies. The differences between the two lambing policies for lamb production traits were consistent across years, in the sense that August-lambing ewes always outperformed June-lambing ewes, although the magnitude of the difference varied. Therefore, whatever ewe cross is chosen for a particular farm it will perform similarly under each policy option for lamb production and selection of a particular cross will depend on other economic traits (eg wool, disease resistance).

Wool Production

Lambing Policy

June-lambing ewes produced more wool than August-lambing ewes but the magnitude of the difference varied between years (0.1 to 1.1 kg) reflecting a significant policy x year interaction. This extra wool may be partly explained by the greater yearly liveweight gains in the June-lambing ewes. However, in 1990 there was no difference in yearly liveweight change between June- and August-lambing ewes yet the June-lambing ewes produced 0.4 kg more wool than the August-lambing ewes at the October shearing.

Reid *et al.* (1988) and Reid & Sumner (1991) found that autumn-lambing Poll Dorset x Romney ewes produced an extra 0.2 kg of wool than their spring-lambing counterparts. No other reports of a lambing policy effect on wool production were found in the literature.

Ewe Cross

Border Leicester x Romney ewes consistently produced more wool per year than PBR ewes and PBR ewes more than SBR ewes. The magnitude of the difference varied between 0.7 and 1.2 kg reflecting a policy x cross interaction for 2-year-old ewes but not for 3-year-old ewes. Poll Dorset x BR ewes produced between 0.3 and 0.5 kg more wool than SBR ewes.

The differences between BR and PBR ewes are similar to those reported by Bigham *et al.* (1978a) who found that BR ewes outperformed Poll Dorset x Romney ewes by 0.6 and 0.4 kg, at the 2- and 3-year-old shearings respectively. The differences in fleece weights observed between BR and PBR ewes agree with earlier reports from the Whatawhata breed comparison trial where Poll Dorset x Romney and BR ewes were compared (Hight & Dalton 1974; Dalton 1976; Dalton 1977).

The extra wool produced by the June-lambing ewes partly compensates for the increased costs associated with lambing out-of-season. Just when the extra wool growth occurs, and the effects this extra wool production has on wool quality, will be examined further in Chapter IV.

Economic Evaluation

An economic evaluation of returns from ewes within each policy and cross was made by assigning economic values to the weight of lamb weaned and average fleece weight of each ewe. It was assumed that 1 kg of greasy wool was valued at $3.00 for BR, PBR and SBR wool (average price for 1990/91 season). The 10 cent/kg premium used in Chapter II for PBR and SBR hogget wool did not exist for ewe fleece wool during the 1990/91 season. The value of 1 kg of lamb liveweight from autumn-born lambs was set at $0.88 (AFFCO schedule, 22 October 1990) while 1 kg of lamb liveweight from spring-born lambs was set at $0.66 (AFFCO Schedule 7 January 1991). The results of the analysis for June-lambing 2- and 3-year-old ewes is shown in Table 3.16, while Table 3.17 shows the results of the analysis for August-lambing 2- and 3-year-old ewes. Border Leicester x Romney ewes generated the most income under a June-lambing policy, primarily due to their increased income from wool. Poll Dorset x BR ewes were the next best income-generating cross and in fact were superior to BR ewes in 1987 and 1988. Suffolk x BR ewes ranked third averaged over all years.

The ranking of ewe crosses for economic performance varied between years and ewe ages under an August-lambing policy. Poll Dorset x BR ewes were the best performing 2-year-old ewes while SBR ewes performed the best as 3-year-old ewes. Once the 2- and 3-year-old financial returns were averaged the BR ewes were marginally superior to SBR and PBR ewes. There was, however, only a $0.25 per head difference between the best and worst cross under an August-lambing policy (averaged across years and ages).

Table 3.16 Value ($) of wool and lamb from June-lambing ewes by age, cross and year.

	2-year-old			3-year-old			Average 2- and 3-year-old
	Wool[1]	Lamb[2]	Total	Wool	Lamb	Total	
BR[3]							
1987	14.40	22.70	37.10	-	-	-	37.10
1988	11.10	19.98	31.08	13.50	19.27	32.77	31.93
1989	17.10	19.36	36.46	14.70	25.43	40.13	38.29
1990	-	-	-	15.30	27.54	42.84	42.84
Mean	14.20	20.68	34.88	14.50	24.08	38.58	37.54
PBR[3]							
1987	12.30	27.28	39.58	-	-	-	39.58
1988	9.00	22.70	31.70	11.40	27.19	38.59	35.14
1989	12.60	18.57	31.17	12.30	23.84	36.14	33.66
1990	-	-	-	11.40	25.70	37.10	37.10
Mean	11.30	22.85	34.15	11.70	25.58	37.28	36.36
SBR[3]							
1987	10.80	26.84	37.64	-	-	-	37.64
1988	10.20	20.59	30.79	9.90	25.78	35.68	33.24
1989	12.60	20.59	33.19	11.70	21.82	33.52	33.35
1990	-	-	-	11.40	26.66	38.06	38.06
Mean	11.20	22.67	33.87	11.00	24.75	35.75	35.75

1 Assumes 1kg greasy wool = $3.00.
2 Assumes 1kg lamb liveweight = $0.88.
3 BR = Border Leicester x Romney, PBR = Poll Dorset x BR, SBR = Suffolk x BR.

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Table 3.17 Value ($) of wool and lamb from August-lambing ewes by age, cross and year.

	2-year-old			3-year -old			Average 2- and 3-year-olds
	Wool[1]	Lamb[2]	Total	Wool	Lamb	Total	
BR[3]							
1987	12.30	20.67	32.97	-	-	-	32.97
1988	10.80	18.28	29.08	12.60	18.61	31.21	30.14
1989	13.50	18.15	31.65	12.00	21.71	33.71	32.68
1990	-	-	-	12.30	19.20	31.51	31.51
Mean	12.20	19.03	31.23	12.30	19.84	32.14	31.82
PBR[3]							
1987	10.80	22.18	32.98	-	-	-	32.98
1988	9.90	20.79	30.69	9.90	22.57	32.47	31.58
1989	10.50	22.84	33.34	9,90	24.62	34.52	33.93
1990	-	-	-	9.90	17.89	27.79	27.79
Mean	10.40	21.94	32.33	9.90	21.69	31.59	31.57
SBR[3]							
1987	9.90	21.05	30.95	-	-	-	30.95
1988	8.10	20.53	28.63	8.70	22.11	30.81	29.72
1989	10.20	18.88	29.08	9.60	25.60	35.20	32.14
1990	-	-	-	9.30	24.42	33.72	33.72
Mean	9.40	20.15	29.55	9.20	24.04	33.24	31.63

1 Assumes 1kg greasy wool = $3.00.
2 Assumes 1kg lamb liveweight = $0.66.
3 BR = Border Leicester x Romney, PBR = Poll Dorset x BR, SBR = Suffolk x BR.

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Table 3.18 Total value of returns ($/ewe) by policy and cross for a simulated flock (structure: 25% = 2-year-old ewes, 75% = mixed aged ewes).

	Ewe Policy	
	June	**August**
BR[1]	37.65	31.91
PBR	36.50	31.77
SBR	35.28	32.32

[1] BR = Border Leicester x Romney, PBR = Poll Dorset x BR, SBR = Suffolk x BR.

The total income generated from lamb and wool within each policy and cross for a simulated flock with 25% 2-year-old ewes and 75% mixed aged is shown in Table 3.18. It is assumed here that the performance of mixed aged ewes is the same as the performance of 3-year-old ewes. The rankings of each ewe cross changed between policies, BR ewes being ranked first at the June lambing while SBR ewes performed marginally better than BR or PBR ewes at the August lambing. Differences in production at the ewe hogget stage (Chapter II) translated into an average advantage (over three years) to the BR hoggets of $1.80/yr compared with the PBR and SBR hoggets. These differences in production are based on individual ewe returns while in practice overall returns are a function of both individual ewe returns and stocking rate. No attempt has been made at this stage to equate the stocking rates between the two policies and in fact they are likely to differ such that returns per hectare are likely to be similar for the two policies (Hawkins *et al.* 1989).

In summary, the BR ewes performed best in the June-lambing policy and, in the absence of any large cross differences in the August-lambing policy, the BR cross would be the preferred choice for farms having a mix of June- and August-lambing ewes (particularly when their hogget performance is accounted for). However, differences between crosses were generally small relative to between-year differences. One of the major findings of this study was the greater level of wool production in June-lambing ewes. Chapter IV further investigates this phenomenon by examining in more detail wool quality and production differences between the three crosses within either a June- or August-lambing policy.

CHAPTER IV

THE EFFECTS OF OUT-OF-SEASON BREEDING ON WOOL PRODUCTION

ABSTRACT

The effects of lambing policy (June- or August-lambing) and ewe cross on midside patch wool growth and wool quality traits were studied throughout a 12 month period. Three ewe crosses, namely Border Leicester x Romney (BR), Poll Dorset x BR (PBR) and Suffolk X BR (SBR), all 3-year-old ewes, were used. Twenty ewes of each cross within each lambing policy and balanced for litter size were selected on 13 April 1988 and had midside patches clipped at approximately six-weekly intervals thereafter until 17 May 1989. Annual ewe fleece production was measured in October of each year. The lambing policy groups were managed similarly under commercial farming conditions. June-lambing ewes produced 0.6 and 0.4 kg more greasy and clean wool respectively than August-lambing ewes ($P<0.001$). This extra wool production was not paralleled by a greater total wool growth from midside patches in June-lambing ewes throughout the 392 day measurement period. There was however, a difference in the pattern of wool growth between the two groups. The seasonal decline in wool production that normally occurs over the winter months in August-lambing ewes was minimised in June-lambing ewes. Associated with the extra winter wool production in June-lambing ewes was a significant ($P<0.05$) increase in mean fibre diameter and an increased staple strength ($P<0.001$) when measured at the following October shearing. Wool from the June-lambing ewes was brighter and whiter ($P<0.05$) than that from August-lambing ewes. There was no difference in wool bulk or resilience between the two policies.

Of the ewe crosses investigated, the BR had the highest wool production (4.4±0.1, 3.4±0.1, 3.0±0.1 kg for BR, PBR and SBR respectively , $P<0.001$), mean fibre diameter ($P<0.05$) and wool tensile strength ($P<0.001$). The SBR had the lowest wool production, lowest mean fibre diameter and wool tensile strength but the highest wool bulk figures. The PBR was intermediate between the BR and SBR.

A possible explanation for the increased winter wool production from the June-lambing ewes is their higher feeding levels while they were lactating over the winter, although liveweight change for the 12 month period was similar for each policy. Altered hormone levels associated with pregnancy and lactation could also be an explanation for the difference in wool growth rates.

INTRODUCTION

Wool comprises between 30 and 70% of the annual returns for New Zealand sheep farms (NZMWBES 1991). Determining the effect of out-of-season breeding on the quantity and quality of wool produced from ewes is therefore essential to the development and financial evaluation of these new lamb production systems. This is particularly important when different breeds or crosses are being considered for use in systems which involve both in-season and out-of-season breeding programmes.

Wool production is essentially a continuous process with growth rates being higher in summer than in winter. The fundamental causes of this seasonal cycle of wool growth remain obscure although wool growth is influenced by both photoperiodic effects (Coop 1953; Story & Ross 1960; Hart 1961; Wodzicka-Tomaszewska & Bigham 1968; Sumner & Wickham 1969; Bigham 1974; Bigham *et al.* 1978b; Geenty *et al.* 1984) and by variation in pasture availability and hence intake (Bigham

& Peterson 1976; Allden 1979; Sumner 1979; Sumner 1983; Hawker *et al.* 1984). In most situations these are confounded to a considerable degree because the short days of winter coincide with periods of low pasture availability and quality.

The effects of pregnancy and lactation on wool growth have been well documented (Corbett 1979). Wool growth can decrease by up to 30% during the second half of pregnancy, but a decline in wool growth can occur as early as 28 days after conception (Henderson *et al.* 1970). Reduced wool growth during pregnancy is accentuated by low levels of nutrition. Lactation delays the recovery of wool growth rates in the spring, the largest influence occurring in the first half of lactation (Allden 1979). The combined effects of pregnancy and lactation are to reduce annual fleece weight by 10 to 14%, this reduction being greatest in ewes rearing multiple lambs (Bigham 1986; Parker *et al.* 1991).

Lambing date can influence wool growth rates through variation in the timing of effects of pregnancy and lactation relative to fluctuations in pasture availability. Reid *et al.* (1988) reported that autumn-lambing ewes produced up to 0.1 kg more wool than those lambing in the spring under Northland New Zealand conditions. The present study has shown a wool production advantage of between 0.1 and 1.1 kg to June-lambing ewes compared with August-lambing ewes in the Manawatu region of New Zealand (Chapter III). Fitzgerald (1976) found an 11% difference in wool production between winter (June/July)- and spring (August/September)-lambing ewes but others found no difference (Allden 1956; Kenney & Davis 1975; Arnold *et al.* 1984).

Wool quality, particularly fibre diameter, strength and position of break, can be influenced by nutritional factors (Fitzgerald *et al.* 1984). Reduced fibre diameter during the period of low winter growth has been associated with lower staple strength and higher fleece tenderness (Ross 1965; Geenty *et al.* 1984). Heritability estimates for staple strength have been moderate to high (0.2-0.6) (Bigham *et al.* 1983b) suggesting that staple strength should respond to direct selection.

Furthermore McClelland (1990) recorded a positive genetic correlation between staple strength and fleece weight. The cost of fleece tenderness or low wool staple strength to the national wool clip has been estimated at between $50 and $100 million annually (Ross 1982). Several studies have shown that date of lambing can influence the proportion of tender fleeces (Kenney & Davis 1975; Arnold *et al.* 1984).

The objectives of this study were to determine the time of the year at which differences in wool production observed previously in June-lambing ewes compared to August-lambing ewes occurred and influences that could cause this difference. The effects of lambing policy (June- or August-lambing) and ewe cross on midside patch wool growth throughout a 12-month period, together with their effect on wool quality traits, were therefore studied. It was anticipated that these data would aid in designing appropriate shearing practices that maximise wool production from ewes in out-of-season breeding programmes.

MATERIALS AND METHODS

The trial was located on Massey University's Keeble Farm (40° 10' S), a 220 ha sheep and beef cattle farm located 5 km south of Palmerston North. The experimental design incorporated two lambing policies and three ewe crosses balanced for litter size (ie a 2 x 3 factorial design). Midpoints of lambing were 5 June and 20 August for the two policies.

Three ewe crosses were used as dams of June- and August- born lambs. The ewe crosses were Border Leicester x Romney (BR), Poll Dorset x BR (PBR) and Suffolk x BR (SBR).

The ewes were 3-year-olds from the 1985-born group described in Chapter II. Mating of the June-lambing ewes commenced on 5 January 1988 and was accomplished using a combination of progesterone-impregnated controlled internal drug releasing devices (CIDR Type G, AHI Plastic

Moulding Company, Hamilton, New Zealand) and high ram: ewe ratios (1:10) (Knight *et al.* 1989b). All ewes were mated to mixed-aged Suffolk rams.

Twenty June-lambing ewes of each cross, balanced for litter size (as determined by ultrasound pregnancy diagnosis) and from the first cycle of mating had midside patches (ca. 20x20 cm) cleared on 13 April (d 0). Thirty August-lambing ewes of each cross, mated naturally at the first cycle after the rams were joined on 15 March 1988, were also selected for midside patch clearance on 13 April (d 0). This group had midside patches clipped on d 44 and then, after pregnancy diagnosis on d 70 (24 June), numbers were reduced to 20 per cross balanced for litter size.

Ewes had wool clipped from midside patches at six-weekly intervals from 27 May 1988 to 11 May 1989. The stage of production for policy groups at each sampling time and the respective numbers of each cross within lambing policy are shown in Table 4.1. A letter code is also included to correspond with a particular ewe production state for use in figures throughout this chapter.

Annual ewe fleece production was measured in October of each year and therefore included a period of wool growth outside the midside sampling regimen. Figure 4.1 depicts how shearing dates and 12-monthly fleece production relate to the midside sampling programme.

The June- and August-lambing groups of ewes were managed similarly under commercial farming conditions. Each group was flushed prior to mating by shortening the rotation and increasing pasture allowance. After mating, the rotation was lengthened to control intakes to maintenance levels (ca. 1.0 kg DM/ewe/d). The ewes were set-stocked one week prior to lambing on to pasture covers of 1200 kg/DM/ha. The initial stocking rate for August-lambing ewes was 12-14 ewes/ha while the June-lambing ewes were stocked at 8-10 ewes/ha. The lower stocking rate of the June-lambing ewes was designed to take account of lower winter pasture growth rates (Hawkins *et al.* 1989).

Table 4.1 **Coding system used to relate date of midside sampling, (upper panel) stage of production and (lower panel) number of ewes by policy and cross.**

Date of sampling	Day of trial	June	Code	August	Code
13.04.88	0	initial midside patch clearance			
27.05.88	44	pre-lambing	A	early-pregnancy	H
06.07.88	84	post-lambing	B	late-pregnancy	I
12.08.88	121	late-lactation	C	pre-lambing	A
05.10.88	175	post-weaning	D	post-lambing	B
17.11.88	218	dry-period	E	late-lactation	C
05.01.89	266	pre-mating	F	post-weaning	D
15.02.89	307	post-mating	G	dry period	E
29.03.89	349	early-pregnancy	H	pre-mating	F
11.05.89	392	late-pregnancy	I	post-mating	G

Date	Day of trial	June			August		
		BR[1]	PBR[1]	SBR[1]	BR	PBR	SBR
13.04.88	0	20	20	20	30	30	30
27.05.88	44	15	18	19	14	15	16
06.07.88	84	15	18	19	14	15	16
12.08.88	121	15	18	19	13	16	16
05.10.88	175	15	17	19	14	15	16
17.11.88	218	15	13	16	13	15	16
05.01.89	266	15	12	15	12	16	14
15.02.89	307	15	12	14	12	15	14
29.03.89	349	15	10	14	12	14	14
11.05.89	392	10	10	13	9	14	13

[1] BR = Border Leicester x Romney, PBR = Poll Dorset x BR, SBR = Suffolk x BR.

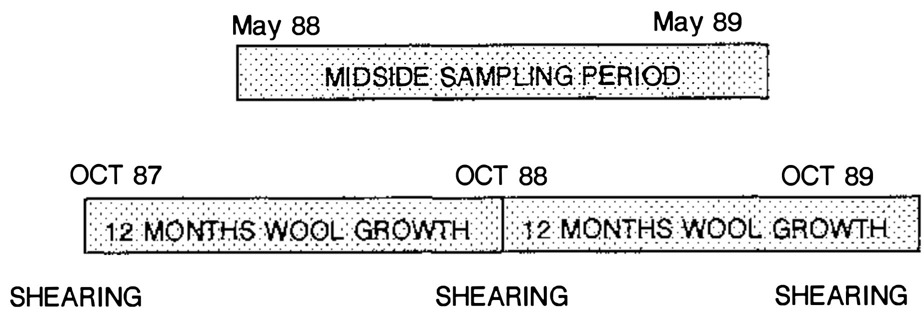


Fig. 4.1 **Relationship between shearing patterns and midside sampling regimen.**

During lactation average pasture cover, measured weekly using the Ellinbank Pasture Meter (Earle & McGowan 1979), was kept above 1000 kg DM/ha by adding extra paddocks to the area available to the lambed ewes from cattle or hogget grazing areas. If pasture cover increased above 1500 kg DM/ha, which was the case in late spring for the August-lambing group, cattle were introduced to consume the excess pasture growth.

Ewes were drenched routinely at docking (when lambs were ca. 3 weeks old) with ivomectin liquid (Merck Sharp & Dohme NZ Ltd) and thereafter when average faecal eggs counts of a sample of 10-20 ewes rose above 500-700 eggs per gram (epg). Lambs were weighed at birth, tagged and identified to their dam. Ewes that failed to lamb or to rear a lamb, or lost one of a pair of twin lambs, were excluded from the data set. The June-lambing ewes were remated on 4 January 1989 following the same procedure as in the previous year while mating for the August-lambing ewes was on 15 March 1989. No pregnancy diagnosis was undertaken for the second pregnancy so that all litter size analyses refer to the first pregnancy or lactation.

During the autumn of 1989, 14 ewes (evenly distributed between crosses) showed clinical signs of facial eczema and were excluded from the trial at the next midside patch clipping.

Measurements

Ewe Liveweight

Unfasted ewe liveweights were taken at the time of midside sampling. Ewes were weighed within 1 hour of leaving pasture using electronic load bar scales (Tru-Test Distributors Ltd, Auckland). Fasted liveweights were not practical because of the possible deleterious effects on ewe and lamb productivity. Liveweights immediately post-lambing were calculated by taking liveweight prior to lambing (d 44 for the early ewes and d 121 for the normal ewes, Table 4.1) and subtracting the total liveweight of lambs born together with a constant allowance for the weight of fluids and placenta of 40% of the total birth weight of lambs (Rattray *et al.* 1974; Robinson *et al.* 1977). Post-shearing liveweights were calculated by subtracting the greasy fleece weight from the liveweight taken just prior to shearing (d 175).

Midside Wool Growth

Midside wool growth was measured by means of the sequential samples taken from the right midside of the ewes while they lay on a flat surface (Bigham 1974). An initial patch measuring 20 cm x 20 cm was cleared of wool using Oster clippers (size 001) and size 40 blades. An area of ca. 100 cm^2 was delineated within this patch using an electronic tattooing instrument (J. Murray, Sydney, Australia). At subsequent clippings the patch area was measured using callipers (Mitutoyo, Tokyo) and all comparisons of wool growth were made on the basis of wool weight per unit skin area for each sampling period (Short & Chapman 1965). Each wool sample was stored in an untied plastic bag for further analysis.

The weight of each greasy midside sample was recorded after conditioning at 20°C and 65% RH (Relative Humidity) for 48 hours. This weight was used in the calculation of clean scoured yield.

During scouring each sample was kept in a terylene mesh bag and passed sequentially through four bowls (36 litres each) of inorganic solvents (Table 4.2). Samples remained in each bowl for three minutes and squeeze rollers removed excess liquid between bowl transfers. After the final bowl the wool was spun dry, dried in a forced draught at 82°C and then returned to the conditioning room for 48 hours to establish correct moisture regain. Clean weight and yield (expressed as the ratio of clean to greasy weight) were then recorded.

Table 4.2 Wool scouring procedure (after Elgabbas 1986).

Bowl	Temp (°C)	Detergent (ml)[a]	Na_2CO_3(g)	$NaHCO_3$(g)	pH
1	55	8	51	-	9.5
2	51	23	-	227	8.2
3	46	19	-	-	8.1
4	15	Cold rinse	-	-	7.6

[a] A technical grade of nonyl phenol condensed ethylene oxide.

Wool Production

Greasy fleece weight (GFW) was recorded immediately after shearing (belly wool included) on an electronic weighing system (Tru-Test Distributors Ltd, Auckland). After each shearing and weighing, a midside sample (ca. 10 g) of fleece wool was removed, stored in a plastic bag, conditioned and scoured using the method described earlier.

Clean scoured yield of the sample was calculated as a ratio of clean weight to greasy weight where the clean weight was that obtained after wool had been conditioned at 20°C and 65% RH for 48 hours. Clean fleece weight (CFW) at the two shearings was calculated from GFW and yield measurements. A further sample from the side contralateral to that used for midside sampling (ie the left side of the sheep) was clipped at the end of trial (d 392) conditioned, scoured and tested for mean fibre diameter, colour, tensile strength, yield, bulk and resilience.

Mean Fibre Diameter

Estimates of Mean Fibre Diameter (MFD) were made on the scoured midside samples using the airflow technique (Anderson 1954; Ross 1958). Two 2.5 g samples were measured in the apparatus and, because samples were short, it was not necessary to card the wool before testing. Some midside samples had clean weights of less than 2.5 g, the weight for which the original apparatus was calibrated. For these samples, the airflow apparatus was adapted to process 1 g samples. Sumner (1969) found that no bias would be introduced by the analysis of 1 g samples, there being a near perfect relationship (r = 0.99) between the two estimates of diameter. Mean Fibre Diameter was calculated on two 2.5 g scoured sub-samples from the October 1988 shearing and on the d 392 contralateral sample.

Tensile Strength

Greasy staples taken from the midside at shearing in October 1988 and from the contralateral sample on d 392 were tested for tensile strength on a Hounsfield tensiometer (McClelland 1990). Five staples per fleece were selected for testing with all measurements being made in a controlled humidity laboratory (20°C, 65% RH). The butt ends of staples were securely clamped between the fixed jaws of the tensiometer and the staple tip secured in the movable jaws. A test length of 8-10 cm, depending on ewe cross, was measured. Tension was applied by means of a hand-wound thread until staples showed evidence of breakage. The load at which the break first began to occur was recorded and fibres were then cut from between the jaws and weighed to the nearest mg. If fibre slippage was evident during the pull the staple was removed and replaced with another staple.

Clean weight of wool tested was calculated as the product of greasy weight and the yield recorded on a sub-sample of wool from the same midside area. Tensile strength was expressed on a clean weight basis, as the mean kg force per gram per m of length (N/Ktex) using the following relationship (after Parker 1990).

N/Ktex	= kg/g x (9.80665/length)
where 1 N	= 9.80665 kg
1 Ktex	= 1 g of fibre per metre in length
length	= (100 cm/length of test staple (cm))
Thus if length	= 8.0 cm there are 12.5 Ktex/g of fibre.

Bulk and Resilience

These were measured on clean scoured and carded samples from the October 1988 shearing and from the contralateral sample taken on d 392 using a WRONZ bulkometer (Dunlop *et al.* 1974; Ross *et al.* 1977). The procedure used was as follows (after Bigham *et al.* 1984a):

(1) take 10 g samples of scoured carded wool

(2) load the sample to a pressure of 30 gf/cm^2 (piston plus 1000g added weight) and allow to stand for 30s

(3) remove loaded piston from sample and allow to recover for 30s

(4) load the sample again to 30 gf/cm^2 for 30s (record this as H_{30}cm)

(5) remove the load again for 30s

(6) remove the 1000g weight from the piston

(7) load the sample (unloaded piston) to a pressure of 10gf/cm^2 for 30s (record this as H_{10}cm)

(8) calculate loose wool bulk as (cm^3/g) $H_{10} \div 2$

(9) calculate resilience as (cm^3/g) $(H_{10} - H_{30}) \div 2$

Colour

Two 3g scoured and carded sub-samples from the midside samples collected at the October 1988 shearing and the contralateral sampling on d 392 were colour-tested using a Hunterlab D 25 D2M Colorimeter (Hammersley & Thompson 1974). The Commission Internationale de l'Eclairange (CIE) (1971) tristimulus values X,Y and Z were measured with each value representing an object's ability to reflect white light in the red (X), green (Y), and blue (Z) areas of the colour spectrum (Bigham *et al.* 1984b). All three values are required to express the true colour of a particular illuminant. As the samples were not degreased after scouring, residual grease could impair the whiteness of the samples. Therefore each sample was measured on two faces and the average of the four readings was recorded for each sample (Elgabbas 1986). Values of Y-Z, an indicator of the yellowness of wool (with higher values indicating yellow discolouration), were also computed (Edmunds 1977).

Statistical Methods

Data relating to midside wool growth, wool characteristics (eg tensile strength), and animal liveweights, were subjected to univariate analysis of variance at each sampling time to test the effects of breeding policy (June v. August), ewe cross, litter size and their interactions. Litter size was taken retrospectively as the number of lambs weaned. The univariate analysis of variance was considered appropriate as use of repeated measures analysis would have decreased the number of measurements available because some ewes were progressively removed from the trial (eg due to death, facial eczema or failure to rear a lamb). However, results of these analyses must be interpreted with caution in recognition of the fact that the sequential samples represented repeated measurements of each trait on the same animal (Gill & Hafs 1971).

The model used to analyse midside wool growth, MFD, fleece characteristics and animal liveweights was therefore:

$$Y_{ijkl} = \mu + P_i + C_j + L_k + PC_{ij} + PL_{ik} + CL_{jk} + PCL_{ijk} + e_{ijkl} \qquad \textit{(Model 4.1)}$$

where

Y_{ijkl}	=	an observation on the *l*th ewe of *i*th policy, *j*th cross and *k*th litter size
μ	=	the general mean
P_i	=	the fixed effect of the *i*th breeding policy (i=1 or 2)
C_j	=	the fixed effect of the *j*th cross (j=1...3)
L_k	=	the fixed effect of the *k*th litter size (k=1 or 2)
PC_{ij}	=	the interaction of the *i*th policy with the *j*th cross
PL_{ik}	=	the interaction of the *i*th policy with the *k*th litter size
CL_{jk}	=	the interaction of the *j*th cross with the *k*th litter size
PCL_{ijk}	=	the interaction of the *i*th policy with the *j*th cross and the *k*th litter size
e_{ijkl}	=	the random residual associated with an observation on the *l*th ewe of the *i*th policy, the *j*th cross and the *k*th litter size

Differences between group means were tested according to pre-planned comparisons using t-tests (Snedecor & Cochran 1967). Data are expressed in terms of means ± SEM. Interaction terms that were not significant ($P>0.05$) were deleted from the model. All statistical analyses were performed using the Statistical Analysis System computer package (SAS 1985).

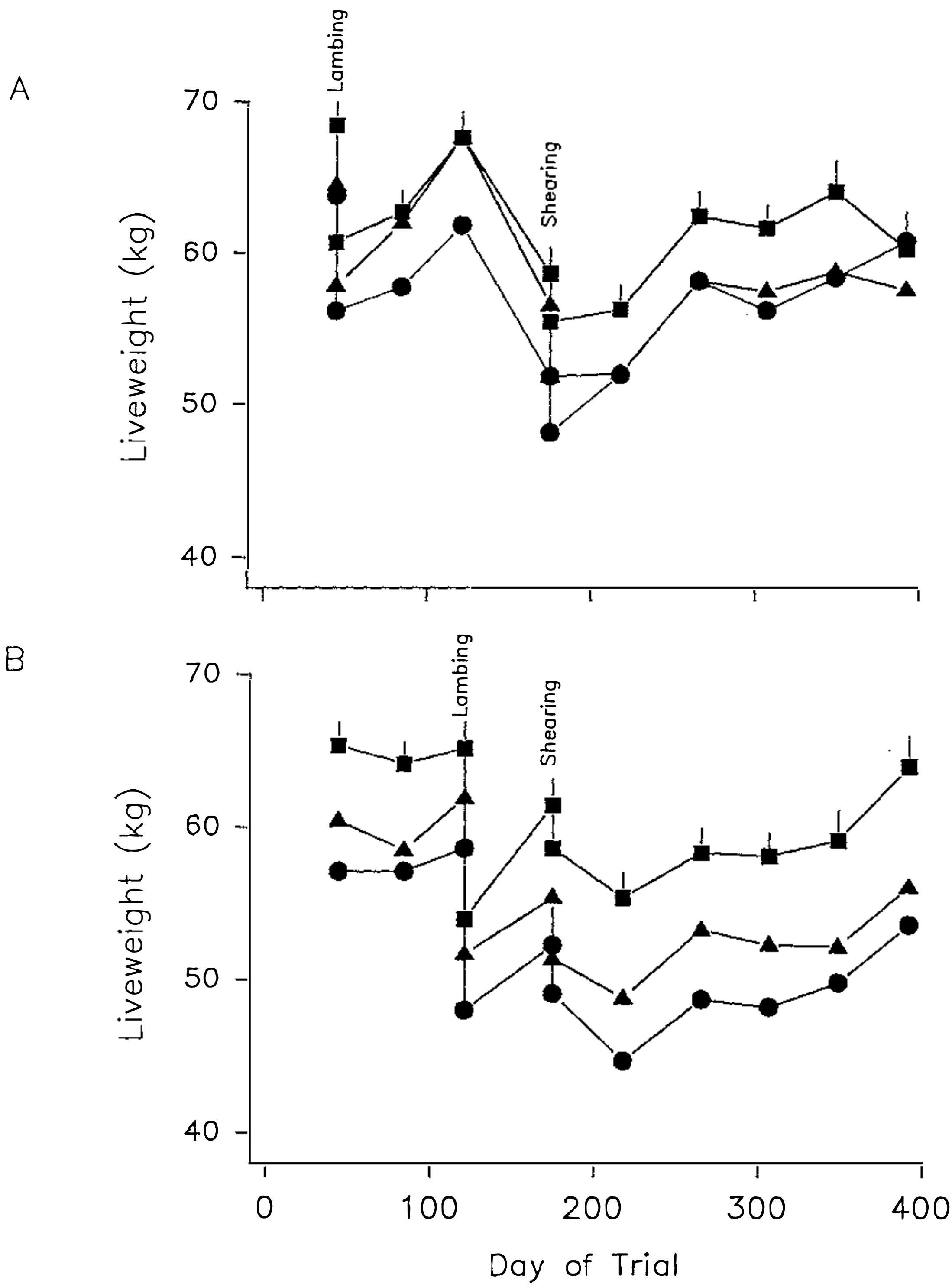
RESULTS

Ewe Liveweights

The liveweights for the three ewe crosses within each breeding policy are shown in Fig 4.2. On average June-lambing ewes were 5 kg heavier (66.1 ± 1.1 v. 61.1 ± 0.9 kg, $P<0.001$) at the initial midside patch clearance on d 0 and remained heavier throughout the trial except for d 84, d 175 and d 392. Both groups of ewes lost approximately 5 kg during the lambing period but the June-lambing group gained 5.4 kg over the 12 week-lactation period compared with a 1.6 kg (fleece weight-adjusted) weight loss by the August-lambing group. The June-lambing ewes weighed 65.5 ± 0.8 kg at weaning (d 121) compared with 49.6 ± 0.9 kg (d 218) for the August-lambing group. However, June-lambing ewes lost this weight advantage from weaning (d 121) to the start of flushing (d 218) while the August-lambing ewes gained 3.3 kg (d 121 to d 307) during the corresponding period. The total liveweight gain by the June-lambing group (mean of all ewe crosses) over the flushing and mating periods was 6.2 kg compared with 0.8 kg for the August-lambing group. Liveweight differences generated during the previous spring had almost disappeared by the end of the trial (d 392) (59.1 v. 57.9 kg, $P>0.10$).

Averaged across policies the Suffolk cross (SBR) ewes were heavier ($P<0.001$) than the BR ewes which in turn were heavier than the PBR ewes (Fig 4.2). Liveweights of SBR ewes fluctuated to a smaller extent than those of the other crosses throughout the 12 months of the trial. There was a significant ($P<0.01$) policy x cross interaction only on d 392 when the PBR and BR June-lambing ewes weighed more than their August-lambing peers whereas this was not the case for the SBR ewes. All other policy x cross interactions were non-significant.

June-lambing ewes that had been diagnosed as bearing twin lambs were heavier than June-lambing ewes diagnosed as bearing a single lamb on d 44. This was not the case for the August-lambing ewes where on d 175 the single-rearing ewes were significantly ($P<0.05$) heavier than twin-rearing ewes.



CODE										
	JUNE	A	B	C	D	E	F	G	H	I
	AUGUST	H	I	A	B	C	D	E	F	G

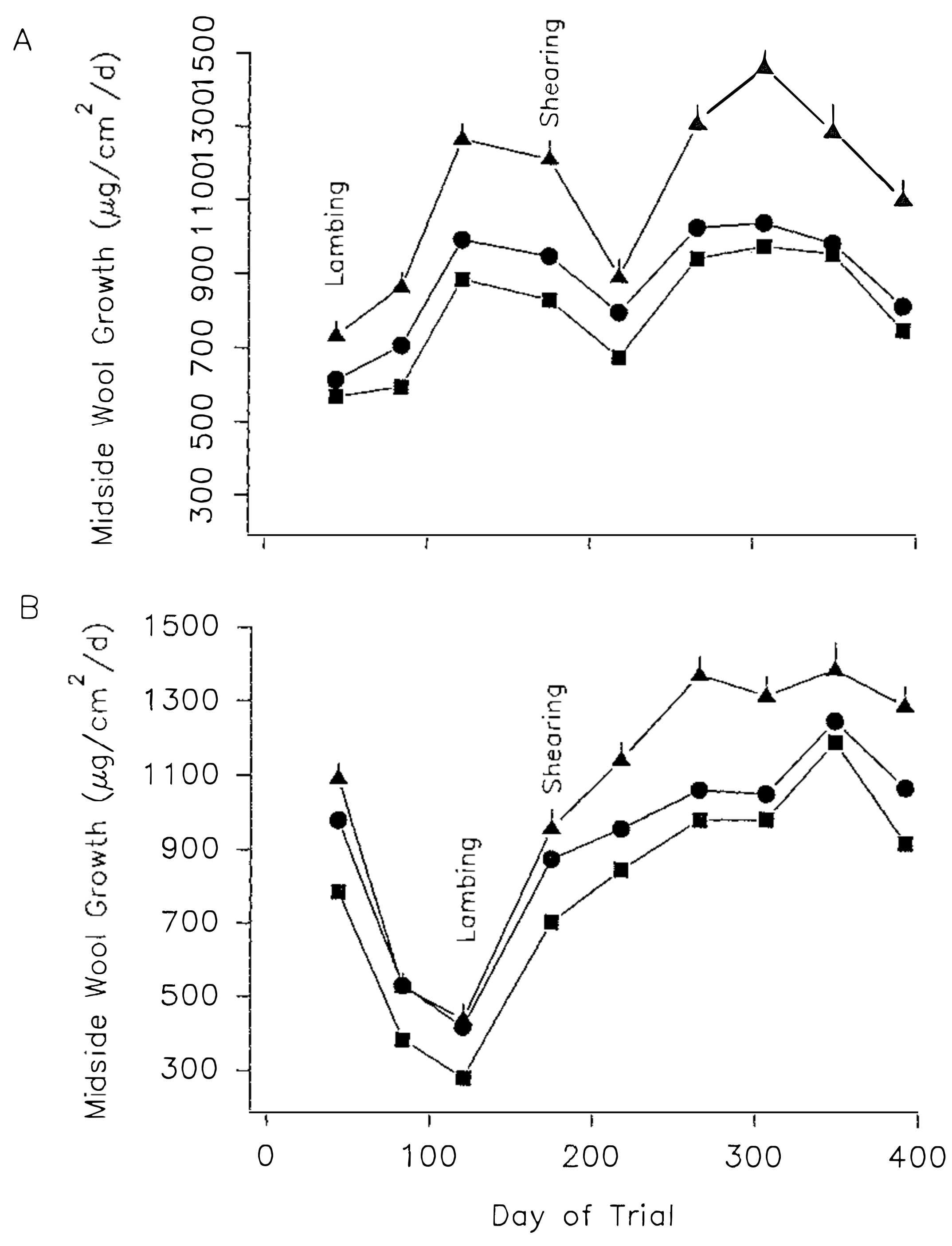
Fig 4.2 **Mean liveweights (±SEM) of Border Leicester x Romney (BR) (▲), Poll Dorset x BR (●) and Suffolk x BR (■) June (A)- and August (B)- lambing ewes. For details of codes see Table 4.1.**

The same was true on d 307 when the August-lambing ewes were in their dry period. This reflects a significant ($P < 0.05$) policy x litter size interaction during some stages of the trial.

Midside Wool Growth

There was no significant difference between breeding policies in total wool growth from midside patches clipped during the 392 days of the trial (Table 4.3). However, there were significant differences in the rate of wool growth during periods to every sampling time except d 266 and d 307. The main difference between the June- and August-lambing ewes was the much flatter wool growth curve of the June-lambing ewes (Fig 4.3). The peak wool growth rate (mean of all ewe crosses) for the June-lambing ewes (1153 ± 28 $\mu g/cm^2$/day to d 307) was only 1.8 times the lowest rate (636 ± 21 $\mu g/cm^2$/day to d 44). By contrast the highest recorded wool growth rate for the August-lambing ewes (1249 ± 37 $\mu g/cm^2$/day to d 349) was 3.3 times the lowest recorded figure during pregnancy (379 ± 22 $\mu g/cm^2$/day to d 121). The wool growth rate of the August-lambing ewes declined to a low point just prior to lambing (d 121) and then rose to a peak in March (d 349) coincident with flushing. The wool growth rate of the June-lambing ewes had two flatter peaks, one during lactation in August (d 121 to 175) and one during January to March (d 266 to d 349 coinciding with mating and early pregnancy) (Fig 4.3).

Averaged across policies the Border Leicester x Romney (BR) ewes grew significantly ($P < 0.001$) more wool on the midside during the whole trial than PBR or SBR ewes (Table 4.3) but there was no difference in total midside wool production between PBR and SBR ewes. This greater wool production by the BR ewes was apparent at all sampling times (Fig 4.3) except for d 84 and d 121 in the August-lambing policy group. The August-lambing PBR ewes outperformed the August-lambing SBR group as did June-lambing PBR ewes on every occasion except to d 44 and from d 349 to d 392.



CODE										
	JUNE	A	B	C	D	E	F	G	H	I
	AUGUST	H	I	A	B	C	D	E	F	G

Fig 4.3 Midside wool growth during approximately 6 week periods to the days shown in Border Leicester x Romney BR (▲), Poll Dorset x BR (●) and Suffolk x BR (■) June-(A)- and August (B)-lambing ewes. For details of codes see Table 4.1.

The difference between the June- and August-lambing groups was greater from d 84 to d 121 in BR ewes (1227±47 v. 439±41 μg/cm²/day) than in PBR (1022±38 v. 398±38 μg/cm²/day) or SBR (873±38 v. 279±37 μg/cm²/day) ewes.

Litter size did not influence total wool growth during the trial (Table 4.3). There was no apparent difference in wool growth rate between ewes rearing singles or twins except during the period to d 84 when ewes rearing singles grew 621±18 μg/cm²/day while those rearing twins grew 549±25 μg/cm²/day ($P<0.10$). Other than those mentioned previously, all interactions between the main effects were non-significant.

Table 4.3 Effects of breeding policy, cross and litter size on total midside wool growth from d 0 to d 392 (Mean ± SEM).

	No.	Wool growth (mg/cm²)
Breeding Policy		
June	29	365±11
August	26	362±10
Cross[1]		
BR	16	424±14[b]
PBR	20	346±13[a]
SBR	19	315±12[a]
Litter size		
1	36	357±9
2	19	367±12

[1] BR = Border Leicester x Romney, PBR = Poll Dorset x BR, SBR = Suffolk x BR.

[ab] Means within main effects having superscripts with letters in common are not significantly different ($P>0.05$).

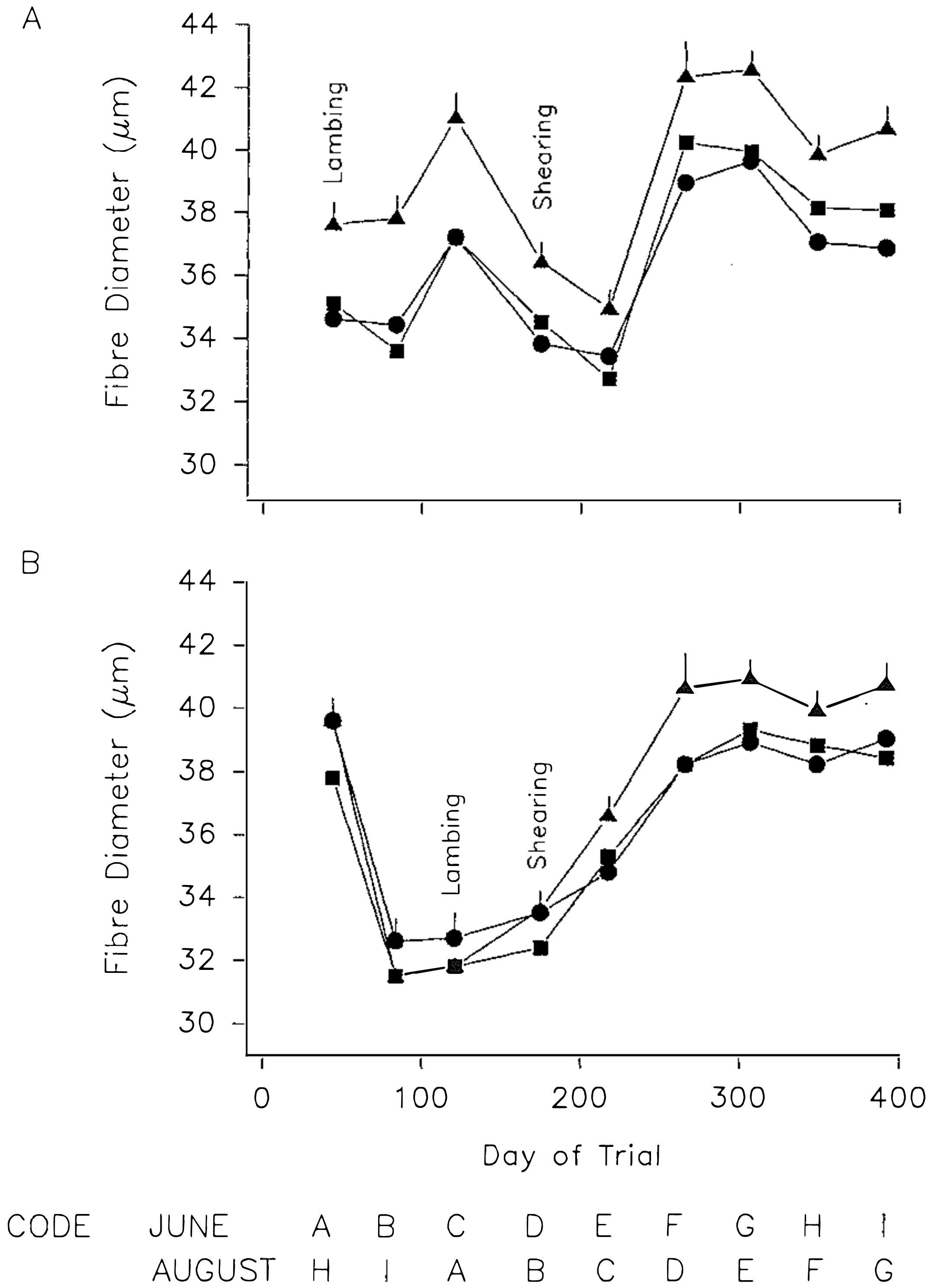


Fig. 4.4 **Mean fibre diameter (MFD) measured on midside wool samples during approximately 6 week periods to the days shown in Border Leicester x Romney (BR) (▲), Poll Dorset x BR (●) and Suffolk x BR (■) June (A)- and August (B)-lambing ewes. For details of codes see Table 4.1.**

Fibre Diameter

Breeding policy significantly ($P<0.05$) influenced MFD at all periods to d 307 with the differences in MFD (Fig 4.4) paralleling the major differences in wool growth rates (Fig 4.3). June-lambing ewes had a lower MFD (mean of all ewe crosses) at d 44 compared to the August-lambing ewes but as midside wool growth rate increased throughout the lactation of the June-lambing ewes from d 84 to d 175 their MFD were significantly ($P<0.001$) higher than those of the August-lambing ewes. The August-lambing ewes had higher MFD on d 218 than the June-lambing ewes but on d 266 and d 307 the June-lambing ewes had higher MFD. There was no significant difference in MFD between the June- and August-lambing ewes at d 349 and d 392.

The period of maximum wool growth (January-February) coincided with the period when MFD was at its maximum. There was a slightly smaller range in MFD over the whole trial in the June-lambing ewes (33.7-40.7 μm) compared with the August-lambing ewes (31.2-39.0 μm).

Averaged across policies, Border Leicester x Romney (BR) ewes had the highest ($P<0.05$) MFD of wool within each lambing policy while there was no difference in MFD between PBR and SBR ewes. There was, however, a significant ($P<0.05$) policy x cross interaction for MFD at d 84 and d 121. On both of these occasions June-lambing BR ewes had a higher MFD than PBR or SBR ewes while there was no effect of cross on MFD in August-lambing ewes.

Mean fibre diameter was not influenced by litter size throughout the experiment and, with the exception of the policy x cross interactions at d 84 and d 121, interactions between the main effects were non-significant.

Greasy Fleece Weight

Fleece weights at each shearing included a period of wool growth outside the 392 days of midside sampling (Fig 4.1). June-lambing ewes produced significantly ($P<0.001$) more greasy wool than August-lambing ewes (Tables 4.4 and 4.5). Border Leicester x Romney (BR) ewes had the highest GFW at both shearings while the PBR ewes produced more than the SBR ewes at the October 1988 shearing ($P<0.001$, Table 4.4) but there was no difference between these two crosses at the October 1989 shearing (Table 4.5).

There was no difference in GFW between ewes rearing singles v. twins at the October 1988 shearing (Table 4.4) and at the October 1989 shearing (Table 4.5)

Clean Scoured Yield

There was no difference between June- or August-lambing ewes in clean scoured yield at the October 1988 shearing (Table 4.4) but the June-lambing ewes had a higher yield than the August-lambing ewes at the October 1989 shearing ($P<0.001$, Table 4.5).

Border Leicester x Romney (BR) ewes had the highest yielding wool in 1988 but for the 1989 shearing the yields of wool from BR and SBR ewes were similar while the PBR ewes had the lowest yield ($P<0.05$).

Clean scoured yield was higher for ewes rearing singles than for those rearing twins at both shearings ($P<0.05$).

Clean Fleece Weight

June-lambing ewes produced significantly ($P<0.001$) more clean wool than August-lambing ewes at both the October 1988 and October 1989 shearings (Tables 4.4 and 4.5). Ewe cross significantly ($P<0.001$) influenced clean fleece weight (CFW) with BR ewes producing 0.8 and 1.1 kg more wool than the PBR and SBR ewes in 1988, while in 1989 the differences were 0.8 and 0.9 kg respectively. The PBR ewes produced more clean wool than the SBR ewes (0.3 kg) at the October 1988 shearing but there was no difference at the October 1989 shearing. Litter size did not influence CFW at either shearing.

Mean Fibre Diameter

The MFDs measured on contralateral samples taken on d 175 and d 392 May of the trial are presented in Tables 4.4 and 4.5. The June-lambing ewes had a higher MFD than the August-lambing ewes on d 175 but not on d 392 of the trial. The BR ewes had higher MFD than either the PBR or the SBR ewes at both d 175 and d 392 of the trial. Litter size had no effect on MFD.

Table 4.4 Effects of breeding policy, cross and litter size on greasy fleece weight, clean fleece weight, yield and mean fibre diameter at the October 1988 shearing (d 175) (Mean±SEM).

	No.	GFW[1] (kg)	CFW[2] (kg)	Yield	MFD[3] (μm)
Breeding policy					
June	51	3.9±0.1^{b}	2.9±0.1^{b}	0.74±0.01	38.7±0.4^{b}
August	45	3.3±0.1^{a}	2.5±0.1^{a}	0.74±0.01	37.5±0.3^{a}
Cross[4]					
BR	29	4.4±0.1^{c}	3.3±0.1^{c}	0.76±0.01^{b}	39.9±0.4^{b}
PBR	33	3.4±0.1^{b}	2.5±0.1^{b}	0.73±0.01^{a}	37.3±0.4^{a}
SBR	34	3.0±0.1^{a}	2.2±0.1^{a}	0.73±0.01^{a}	37.1±0.4^{a}
Litter size					
1	63	3.6±0.1	2.7±0.1	0.75±0.01^{b}	37.9±0.3
2	33	3.6±0.1	2.6±0.1	0.73±0.01^{a}	38.2±0.4

[1] Greasy Fleece weight for period October 1987 to October 1988.
[2] Clean fleece weight for period October 1987 to October 1988.
[3] Mean fibre diameter.
[4] BR = Border Leicester x Romney, PBR = Poll Dorset x BR, SBR = Suffolk x BR.
[abc] Means within columns and main effects having superscripts with letters in common are not significantly different (P>0.05).

Table 4.5 Effects of breeding policy, cross and litter size on greasy fleece weight, clean fleece weight and yield at the October 1989 shearing, and mean fibre diameter (measured on a contralateral sample on d 392) (Mean±SEM).

	No.	GFW[1] (kg)	CFW[2] (kg)	Yield	MFD[3] (μm)
Breeding policy					
June	36	4.1±0.2[b]	3.3±0.1[b]	0.81±0.01[b]	37.5±0.4
August	36	3.3±0.2[a]	2.6±0.2[a]	0.79±0.01[a]	37.6±0.4
Cross[4]					
BR	26	4.3±0.2[b]	3.5±0.2[b]	0.80±0.01[b]	38.6±0.4[b]
PBR	17	3.5±0.2[a]	2.7±0.1[a]	0.78±0.01[a]	36.9±0.4[a]
SBR	29	3.3±0.2[a]	2.6±0.1[a]	0.81±0.01[b]	37.1±0.4[a]
Litter size					
1	45	3.5±0.2	2.8±0.1	0.81±0.01[b]	37.6±0.3
2	27	3.9±0.2	3.1±0.2	0.79±0.01[a]	37.5±0.4

[1] Greasy fleece weight for period October 1988 to October 1989.
[2] Clean fleece weight for period October 1988 to October 1989.
[3] Mean fibre diameter.
[4] BR = Border Leicester x Romney, PBR = Poll Dorset x BR, SBR = Suffolk x BR.
[abc] Means within columns and main effects having superscripts with letters in common are not significantly different (P>0.05).

Bulk and Resilience

Breeding policy had no effect on bulk or resilience of samples taken on d 175 and d 392 of the trial (Tables 4.6 and 4.7). At d 175, the highest bulk wool came from SBR ewes (32.1±0.8 cm^3/g) followed by PBR (28.1±0.8 cm^3/g) and then BR ewes (22.6±0.8 cm^3/g) ($P<0.001$). A similar pattern was apparent at d 392. Suffolk x BR ewes also had higher resilience readings than PBR and BR ewes ($P<0.001$). Litter size had no effect on either bulk or resilience.

Table 4.6 Effects of breeding policy, cross and litter size on wool bulk, resilience and staple strength on d 175 (Mean±SEM).

	No.	Bulk (cm^3/g)	Resilience (cm^3/g)	Tensile Strength (N/Ktex)
Breeding policy				
June	51	26.9±0.7	11.6±0.4	31.0±1.7[b]
August	45	28.2±0.8	12.2±0.3	23.5±1.5[a]
Cross[1]				
BR	29	22.6±0.8[a]	9.7±0.5[a]	28.6±2.1[b]
PBR	33	28.1±0.8[b]	12.3±0.4[b]	29.9±1.9[b]
SBR	34	32.1±0.8[c]	13.7±0.4[c]	23.1±1.9[a]
Litter size				
1	63	27.8±0.8	12.0±0.3	28.9±1.4
2	33	27.4±0.8	11.9±0.4	25.6±1.9

[1] BR = Border Leicester x Romney, PBR = Poll Dorset x BR, SBR = Suffolk x BR.
[abc] Means within columns and main effects having superscripts with letters in common are not significantly different ($P>0.05$).

Table 4.7 Effects of breeding policy, cross and litter size on wool bulk, resilience and staple strength on d 392 (Mean±SEM).

	No.	Bulk (cm^3/g)	Resilience (cm^3/g)	Tensile Strength (N/Ktex)
Breeding policy				
June	36	25.0±0.7	10.5±0.4	34.6±2.0[a]
August	36	24.7±0.6	10.1±0.3	42.5±1.9[b]
Cross[1]				
BR	26	20.4±0.8[a]	8.5±0.5[a]	49.7±2.8[c]
PBR	17	24.9±1.0[b]	10.3±0.4[b]	41.2±2.2[b]
SBR	29	29.4±0.7[c]	12.2±0.4[c]	24.7±2.0[a]
Litter size				
1	45	25.3±0.6	10.3±0.3	36.9±2.0
2	27	24.5±0.8	10.3±0.4	40.2±2.0

[1] BR = Border Leicester x Romney, PBR = Poll Dorset x BR, SBR = Suffolk x BR.
[abc] Means within columns and main effects having superscripts with letters in common are not significantly different ($P>0.05$).

Tensile Strength

June-lambing ewes had significantly ($P<0.001$) stronger wool on d 175 of the trial than August-lambing ewes (31.0±1.7 v. 23.5±1.5 N/Ktex, Table 4.6). This order was reversed at the end of trial (d 392) when the August-lambing ewes had the strongest wool (42.5±1.9 v. 34.6±2.0 N/Ktex, $P<0.001$, Table 4.7).

The PBR ewes had similar strength wool to BR ewes on d 175 while the weakest wool for this period came from the SBR ewes (Table 4.6). Border Leicester x Romney (BR) ewes produced the strongest wool on d 392 (49.7±2.8 N/Ktex) of the trial ($P<0.001$) and there was a significant ($P<0.001$) difference at this time between the PBR and SBR ewes (41.2±2.0 v. 24.7±2.0 N/Ktex respectively, Table 4.7).

Litter size had no significant effect on wool tensile strength although there was a tendency for ewes with twins to produce more tender wool on d 175 (25.6±1.9 v. 28.9±1.4 N/Ktex, $P=0.12$).

Colour

Tristimulus colour values X, Y and Z and the derived value Y-Z are presented in Tables 4.8 and 4.9. The X and Y values of wool from the June-lambing ewes on d 175 were significantly ($P<0.05$) higher than those of wool from the August-lambing ewes. In contrast, on d 392 the X, Y and Z values for the June-lambing ewes were significantly ($P<0.05$) higher than those of the August-lambing ewes.

Suffolk x BR (SBR) ewes had brighter wool on d 392 than BR ewes (significant Y value difference, $P<0.05$) while there was no difference in Y values between PBR and SBR ewes. No ewe cross differences existed for X or Z tristimulus values but the derived Y-Z value for BR and PBR ewes was lower than the value for SBR ewes on d 392, an indication of better wool colour from the former two crosses. Litter size had no influence on tristimulus colour values at either sampling time. Values for X, Y and Z were generally higher, and the Y-Z value lower, on d 392 compared with d 175, indicating better wool colour during the autumn.

Table 4.8 Effects of breeding policy, cross and litter size on wool CIE tristimulus colour values on d 175 (Mean ± SEM).

	No.	CIE Tristimulus Values			
		X	Y	Z	Y-Z
Breeding policy					
June	51	55.2±0.3[b]	57.0±0.4[b]	53.8±0.5	3.2±0.2
August	45	54.1±0.3[a]	56.1±0.3[a]	53.3±0.4	2.8±0.2
Cross[1]					
BR	29	54.9±0.4	56.6±0.4	53.1±0.6	3.5±0.3
PBR	33	54.8±0.4	56.7±0.4	53.9±0.5	2.8±0.3
SBR	34	54.7±0.4	56.5±0.4	53.7±0.5	2.8±0.2
Litter size					
1	63	55.0±0.3	56.8±0.3	54.1±0.4	2.7±0.2
2	33	54.6±0.4	56.3±0.4	53.0±0.5	3.3±0.3

[1] BR = Border Leicester x Romney, PBR = Poll Dorset x BR, SBR = Suffolk x BR.
[ab] Means within columns and main effects having superscripts with letters in common are not significantly different (P > 0.05).

Table 4.9 Effects of breeding policy, cross and litter size on wool CIE tristimulus colour values on d 392 (Mean ± SEM).

	No.	CIE Tristimulus Values			
		X	Y	Z	Y-Z
Breeding policy					
June	36	58.6±0.3[b]	60.5±0.3[b]	58.6±0.3[b]	1.8±0.1
August	36	57.8±0.3[a]	59.6±0.3[a]	57.8±0.3[a]	1.8±0.1
Cross[1]					
BR	26	57.6±0.3	59.4±0.3[a]	57.5±0.3	1.8±0.1[ab]
PBR	17	58.4±0.3	60.2±0.3[ab]	58.4±0.4	1.6±0.1[a]
SBR	29	58.7±0.3	60.7±0.3[b]	58.7±0.3	2.0±0.1[b]
Litter size					
1	45	58.3±0.2	60.1±0.3	58.3±0.2	1.8±0.1
2	27	58.1±0.3	59.8±0.3	58.1±0.3	1.8±0.1

[1] BR = Border Leicester x Romney, PBR = Poll Dorset x BR, SBR = Suffolk x BR.
[ab] Means within columns and main effects having superscripts with letters in common are not significantly different (P > 0.05).

DISCUSSION

Experimental Design

The aim of this experiment was to determine the yearly wool growth patterns of June- and August-lambing ewes. In particular, the study was designed to identify times of the year at which marked differences between the policies in wool growth were observed which might account for corresponding differences in annual fleeceweight (Reid *et al.* 1988; Reid & Sumner 1991; Chapter III). To achieve this, analyses of the data were on the basis of actual sampling date. Thus at any particular sampling time comparisons were made between lambing policies involving ewes of differing physiological status (Table 4.1). The alternative would have been to carry out analyses at the same physiological status (eg lactation for June-lambing ewes was June-August while for August-lambing ewes it was September-November). However, while the ewes were managed as far as possible under similar conditions, analyses based on comparative stages of production would be compromised by large differences in nutritive value between pastures to which the two ewe policies were exposed. This would make it extremely difficult to interpret any wool growth differences.

Liveweight changes can be considered indicative of nutritional status with net liveweight change of the ewes in each policy throughout the 392 days of the trial reflecting the balance between feed supply and demand. Nutritional or liveweight changes could partially explain differences in wool growth previously observed between the two lambing policies. Thus June-lambing ewes lost 7.5 ± 0.9 kg throughout the 12 months of the trial while August-lambing ewes lost 2.5 ± 0.8 kg. However, at the beginning of the trial the June-lambing ewes weighed 67.2 ± 0.9 kg (reflecting their late-pregnancy state) while the August-lambing ewes, which were in early pregnancy at that time, weighed 60.9 ± 0.8 kg. Therefore the majority of the weight loss measured in the June-lambing ewes was in the products of conception. Both groups of ewes had returned to similar liveweights by the end of the trial (59.1 ± 0.9 v. 57.9 ± 0.9 kg, for June- and August-lambing ewes, respectively). This indicates that, regardless of lambing date or feed supply, ewe liveweight change did not differ greatly between policies and is an indirect indication that, over the whole trial (but not necessarily at specific comparison times), the net balance between feed supply and demand was similar for ewes in each lambing policy.

The decision to analyse on actual sampling date was therefore considered the most appropriate in terms of explaining the differences that occurred in patterns of fleece production and, ultimately, aiding in the design of shearing policies for out-of-season lamb production systems. However, it is clear that in studies of this type, no method exists to make comparisons between policies unconfounded by differences in physiological state or environmental (including nutritional) conditions.

Litter size effects were small and showed little interaction with other main effects. They will therefore not be discussed further in this Chapter.

Fleece Weight

June-lambing ewes produced significantly more greasy wool (0.6 and 0.8 kg) and clean wool (0.4 and 0.7 kg) than the August-lambing ewes at the October 1988 and October 1989 shearings, respectively. This result is consistent with the 0.5 kg average annual greasy wool production advantage to June-lambing ewes over August-lambing ewes reported in Chapter III. Reid *et al.* (1988) also found that autumn-lambing Poll Dorset x Romney ewes produced up to 0.1 kg more wool from March to October than comparable ewes lambing in spring. Likewise Reid & Sumner (1991) noted that ewes lambing in autumn consistently had higher greasy fleece weights in March and October than ewes lambing in the spring. Australian researchers have found small differences in wool production between winter (June/July)- and spring (August/September)-lambing ewes (Allden 1956; Kenney & Davis 1975; Fitzgerald 1976; Arnold *et al.* 1984). However, the climatic conditions are vastly different in Australia compared to New Zealand and make direct comparisons difficult.

Border Leicester x Romney (BR) ewes clipped higher greasy and clean fleece weights than either the PBR or SBR ewes. Poll Dorset x BR (PBR) ewes had higher wool production than SBR ewes in 1988 but not in 1989. The advantage in greasy fleece weight of BR over PBR ewes (0.8-1.0 kg) is in agreement with other research results (Geenty *et al.* 1975; Bigham *et al.* 1978b). No New Zealand data exist in the literature on fleece wool production from crosses between the Suffolk and long-woolled breeds. However, a Canadian study involving the Dorset, Suffolk and Leicester breeds listed yearly fleece wool weight for these breeds as 3.13, 3.29 and 3.97 kg, respectively (Fahmy & Vesely 1977). The lack of a policy x cross interaction suggests that the ranking of the crosses for fleeceweight is similar for each policy.

To summarize, wool production in June-lambing ewes is higher than that in August-lambing ewes and, of the three ewe-crosses studied, the BR ewes produce more wool than either the PBR or SBR ewes.

Midside Wool Growth

Lambing Policy

There was a markedly different pattern of wool growth between the June- and August-lambing ewes. Maximum (summer) midside wool growth was 1.8 and 3.3 times the minimum (winter) wool growth rates for June- and August-lambing ewes, respectively. Thus while both groups of ewes exhibited seasonality of wool production, the June-lambing ewes had a much lower winter depression in both absolute (weight/d) and proportional (% of maximum) terms than the August-lambing ewes.

The cumulative midside wool growth throughout the trial for the two lambing policies is shown in Figure 4.5. The key point is that June-lambing ewes had greater cumulative midside wool production than August-lambing ewes from d 44 to d 175. During this period the June-lambers were in lactation and the post-weaning period while the August-lambers were in late pregnancy and lactation. Between d 175 and d 218 the August-lambing ewes (which were lactating) had greater midside wool production than the June-lambing ewes (which were in the dry period). Towards the end of the trial (d 307 to d 392) the August-lambing ewes also had greater midside wool growth rates so that, by the end of the trial, total cumulative midside wool growth was similar between the two policies.

Reid *et al.* (1988) also observed that wool growth during winter was higher in lactating autumn-lambing ewes than in their pregnant spring-lambing counterparts. Likewise in that trial the only period when wool growth rate was higher in spring-lambing than in autumn-lambing ewes was in September and early October, coinciding with weaning in the autumn-lambing ewes and lactation in the spring-lambing ewes.

Many researchers have observed that wool growth is faster in summer than in winter. Geenty *et al.* (1984) found that wool growth of spring-lambing ewes was lowest in winter (4.0 and 5.0 g/ewe/d for indoor- and outdoor- fed ewes respectively) and greatest in summer for indoor (11.3 g/ewe/d) or spring for outdoor (11.9 g/ewe/d) ewes. Similarly Hawker & Crosbie (1985) observed that summer wool growth rates were more than twice those of winter (11.5 and 9.2 v. 5.5 and 4.4 g/ewe/d) for Romney and Perendale ewes respectively. Ross (1965) studied the lifetime wool growth rates in the Romney breed and characterised the growth patterns into three distinct periods;

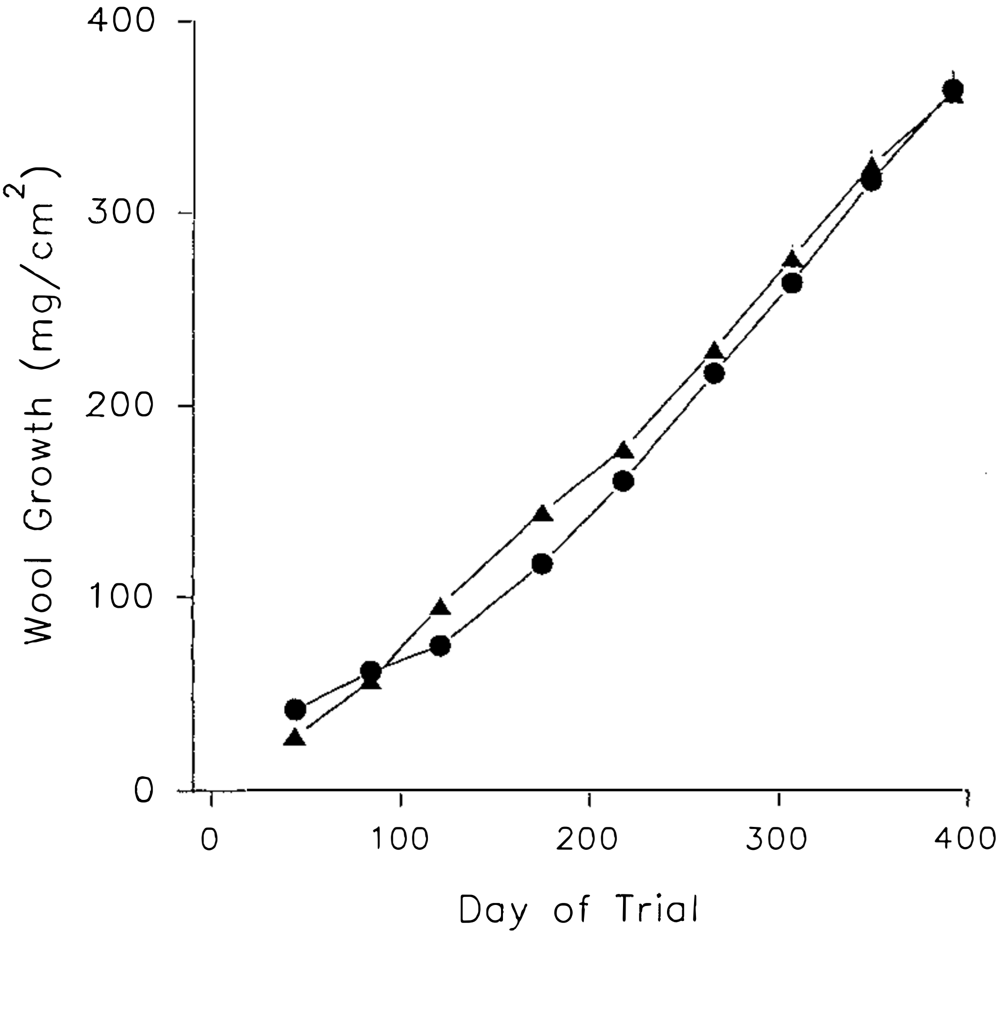


Fig 4.5 **Cumulative midside wool growth of June- (▲) and August- (●) lambing ewes.**

November to March (47% of total growth), March to July (29.5% of total growth) and July to November (23.5% of total growth).

The causes of the winter decline in wool production are not yet completely understood. Nutritional differences, together with the additional stresses of pregnancy and lactation, are probably involved (Corbett 1979). There is an associative relationship between seasonality of wool growth and the seasonal cycles of melatonin (Harris *et al.* 1989) and prolactin (Ortavant *et al.* 1985) secretion or circulating levels. The seasonality of wool growth response is accentuated by an interaction between photoperiod effects on wool growth and level of nutrition (Sumner 1979; Hawker *et al.* 1982; Hawker *et al.* 1984).

Although absolute responses in wool growth rate to increased feeding are approximately twice as high in summer as in winter (Hawker *et al.* 1984), the proportional responses were very similar in the trial of Hawker & Crosbie (1985) which used non-pregnant ewes. No reports were found in the literature on the effects of feeding levels on wool growth in lactating autumn/winter lambing ewes. Increased feeding levels of June-lambing ewes may be one explanation for their greater wool production. During the period d 84 to d 121, the lactating June-lambing ewes had liveweight gains of 127 g/d compared with 30 g/d for the pregnant August-lambing ewes. Rattray *et al.* (1974) found that a single foetus had average liveweight gains of 129 g/d on d 120 of pregnancy and 199 g/d on d 140 of pregnancy. Therefore the August-lambing ewes were probably under considerable nutritional stress throughout the period d 84 to d 121 when their liveweight gain was 30 g/d. These differences in liveweight gain, and hence nutritional status, are likely to account for some of the increased midside wool growth in June-lambing v. August-lambing ewes throughout this period (1045 v. 379 $\mu g/cm^2/d$). However, during their post-weaning period (d 121 to d 175) the June-lambing ewes lost liveweight (180 g/d) but still recorded a higher midside wool growth (993 v. 845 $\mu g/cm^2/d$) than the August-lambing ewes which had liveweight gains of 104 g/d throughout this period. The higher wool production (981 v. 785 $\mu g/cm^2$) recorded in the August-lambing ewes from d 175 to d 218 occurred while these ewes were losing liveweight (79 g/d). During this same period the June-lambing ewes gained liveweight (37 g/d). Thus differences between the policies in midside wool growth at specific times cannot be accounted for solely by differences in nutritional status.

The management objectives during lactation were to offer ewes and lambs pasture with a minimum height of 4 cm (ca. 1000 kg DM/ha). Dry ewes were rationed to a maintenance allowance and pregnant ewes offered maintenance plus an allowance for the growing foetus. Rationing occurred via rotational grazing and adjustment of post-grazing residual dry matters. It therefore seems likely that some of the differences in wool growth observed between June- and August-lambing ewes were a consequence of the deliberate management policy to change ewe feeding levels during pregnancy, lactation and the post-weaning dry period.

The higher fleece weights recorded at shearing (1988 and 1989) in the June-lambing ewes compared with August-lambing ewes were not paralleled by a greater total wool growth on the midside of June-lambing ewes over the 392 days of the trial. A likely explanation for this is that the 12 months of wool growth measured at each of the two shearings (1988 and 1989) included six months of wool growth outside the midside sampling periods (see Figure 4.1). Throughout the period d 0 to d 175, the accumulated midside wool growth from the June-lambing ewes was 144 mg/cm^2 v. 117 mg/cm^2 from the August-lambing ewes. This difference between the two lambing policies was reflected in fleece weight at the October 1988 shearing and suggests that in the 6 month pre-trial period wool growth was the same or greater in June- than in August-lambing ewes.

Accumulated midside wool growth was higher in August- than in June-lambing ewes (247 mg/cm^2 v. 216 mg/cm^2) during the period d 175 to d 392. However, at the 1989 shearing, 6 months after the midside sampling concluded, the June-lambing ewes had higher fleece weights than the August-lambing ewes. Therefore it is likely that the June-lambing ewes grew significantly more wool than August-lambing ewes over the 6 month post-midside sampling period. This is consistent with the increased midside wool growth in June-lambing ewes measured over the lactation period during 1988. In retrospect it would have been desirable to have the interval of midside sampling coincide with the interval between shearings.

Ewe Cross

Border Leicester x Romney (BR) ewes grew more wool throughout the trial than PBR and SBR ewes. Of the four parent breeds used to generate these crosses, the Romney and Border Leicester are recognised as higher wool producers than either the Suffolk or Poll Dorset breeds (Carter & Cox 1982).

The annual wool growth curves did differ between the ewe crosses with PBR ewes having the flattest curve. The ratios of midside wool growth rate in summer (days 266-349) to that in winter (days 0 to 84) were 2.0, 1.8 and 2.1 for BR, PBR and SBR ewes, respectively. The lower seasonal differences in wool production of the PBR are likely to be related to the Poll Dorset being a less seasonal breed (ie less sensitive to photoperiod effects) than the other parent breeds used to generate the ewe crosses.

Policy x Cross Interaction

The superiority of BR ewes over PBR and SBR ewes for midside wool growth in the sampling period to d 121 was of a higher magnitude in June-lambing than in August-lambing ewes. There were no other policy x cross interactions for wool growth measurements. The lack of any major interactions indicates the policy effects on wool growth pattern are not unique to any particular ewe cross.

Wool Quality Traits

Lambing Policy

The flatter wool growth curve of the June-lambing ewes compared with that of the August-lambing ewes was associated with a more narrow range of fibre diameter over the whole year of sampling (7.0 v. 8.5 μm). Mean fibre diameters (MFD) during periods of high wool growth (d 266 to d 349) were 1.2 and 1.3 times greater than those during the winter minimum (d 0 to d 84) for June- and August-lambing ewes, respectively.

The mean fibre diameter (MFD) of contralateral midside samples of fleece wool taken at shearing in October 1988 (d 175) was different between June- and August-lambing ewes (38.7 v. 37.7 μm). The higher wool growth rates recorded over the winter months by the June-lambing ewes would presumabley account for this difference in MFD. Likewise Reid & Sumner (1991) found that wool from spring-lambing ewes was finer than wool from autumn-lambing ewes at the October shearing. The contralateral midside sample clipped on d 392 showed no difference in mean fibre diameter (37.6 v. 37.6 μm) reflecting relatively similar wool growth rates since the last shearing (d 175).

Wool from June-lambing ewes had higher tensile strength values than that from August-lambing ewes on d 175 while on d 392 the reverse was true. Tender (lower tensile strength) wools generally come from sheep with lower fleece weights than sound (high tensile strength) wools. Therefore the higher fleece weights recorded in the June-lambing ewes (resulting from the higher winter wool growth rates during lactation) would account for the sounder wool from the June-lambing ewes on d 175. Likewise during the period prior to sampling on d 392 (ie d 312 to d 392) the August-lambing ewes grew more wool and hence had increased wool tensile strength values. Geenty *et al.* (1984)

found that for each additional 1 g of clean wool growth/d, staple strength increased by approximately 12 N/Ktex. This result agrees with the findings of Reid & Sumner (1991), namely that wool from spring-lambing ewes had a markedly lower tensile strength.

Reduced MFD of wool from August-lambing ewes over the winter months (during pregnancy) would also contribute to their decreased tensile strength (Ross 1965; Hawker & Littlejohn 1989). There was, however, no difference in MFD during the later stages of the trial (d 307 to d 392). The higher tensile strength wools recorded for both June-lambing and August-lambing ewes in the autumn (d 392) are likely to be are a reflection of their higher wool growth rates over summer and hence increased MFD (Bigham *et al.* 1983b).

March-lambing Merino ewes produced 8% more tender fleeces than July-lambing ewes under Australian conditions (Arnold *et al.* 1984). Likewise Kenney & Davis (1975) noted differences of 12% in the proportion of tender wools between winter (June/July)- and spring (August/September)-lambing ewes. Foot & Heazelwood (1988) also found that spring-lambing Merinos tended to have more sound wool than autumn lambers. These results relate to the Australian scene where, unlike in the trial reported here, nutrition during the autumn may be limiting. Hence in that situation wool growth was lower, and there was a higher proportion of tender wools recorded, in the autumn-lambing ewes than in spring-lambing ewes.

Loose wool bulk and resilience values were not affected by lambing policy. There are no reports in the literature of substantial identifiable environmental effects on wool bulk or resilience (Carnaby & Elliott 1980; Bigham *et al.* 1983a; Stobart & Sumner 1991).

Wool from June-lambing ewes was lighter and brighter (higher Y value) than wool from August-lambing ewes on d 175 of the trial. This is most likely a reflection of the higher wool growth during the winter months for the June-lambing group. Another possible explanation is the harder grazing the June-lambing ewes received after weaning (d 121 of trial) and hence possible less contamination from pasture compared to the August-lambing ewes which grazed to higher residual allowances while they were lactating. The Y-Z value (an indicator of yellowness) was not influenced by lambing policy on d 175. Reid & Sumner (1991) also found that wool from spring-lambing ewes was less bright but, contrary to the results from this trial, lambing policy did influence yellowness. The CIE values on d 392 were higher for Y and lower for Y-Z than on d 175, reflecting brighter and less yellow wool in the autumn (d 392) compared with the spring (d 175). However, the wool sampled on d 392 represented 7 months growth, similar to second shear wools, compared to the 12 months growth on d 175. Sumner (1983) has reported that second shear wools are usually brighter and have less yellow discolouration than wools clipped once-yearly. The lower Y-Z values recorded in autumn would be of slight economic significance as current (1992) price differentials between style grades are 5-8 c/kg (W.R. Regnault, *pers. comm.*) and style grades vary between 1.0 and 1.5 CIE Y-Z units (Sumner 1983).

Yellowness and brightness colour-price relations are erratic but there is a general trend that brighter white wools are of greater value (Elliott 1986). June lambing marginally enhances wool brightness although it would be of doubtful economic significance. Maddever *et al.* (1991) estimated that the relative economic value of bright wools would increase by 4.3 cents/kg for each unit increase in Y value.

<u>Ewe Cross</u>

Differences between the winter minimum and summer maximum MFD of 7.1, 5.7 and 7.1 μm were found between BR, PBR and SBR ewes, respectively (averaged across policy). On both occasions that the contralateral samples were clipped (d 175 and d 392), the BR ewes had the highest MFD wool (39.9 and 38.6 μm) compared to the PBR ewes (37.3 and 36.8 μm) and SBR ewes

(37.1 and 37.1 μm). Other researchers have also found that the Suffolk and Poll Dorset breeds have lower MFD than the Romney or Border Leicester breeds (Bigham 1986; Fahmy & Vesely 1977).

Wool from the SBR ewes had the lowest tensile strength values at both sampling periods (23.1 and 24.7 N/Ktex). A staple strength below 25 N/Ktex can be considered a tender wool (Bigham *et al.* 1983b). McPherson (1982) estimated a price differential for each soundness grade of 14.4 cents/kg which equates to approximately 3.0 cents/N/Ktex (G.A. Wickham, *pers. comm.*). The Suffolk has not been previously reported as having tender wool. The increased bulk of the SBR wool may have contributed to the lower tensile strength values as the measurement of tensile strength was the load to break the staple. The bulky SBR wool would take a longer period to stretch the fibre to breaking point compared to less bulky BR and PBR wool (Ross 1960; 1961). There was no difference in tensile strength between the PBR and BR ewes on d 175 but the BR ewes had much sounder wool (higher tensile strength readings) on d 392 than the PBR ewes (49.7 v. 41.2 N/Ktex).

The range of loose wool bulk readings at the two sampling times (d 175 and d 392) for each ewe cross was: BR, 20.4-22.6 cm^3/g; PBR, 24.9-28.1 cm^3/g; and SBR, 29.4-32.1 cm^3/g respectively. These readings fall within the loose wool bulk classifications of strong/medium crossbred 19-24 cm^3/g (BR), medium wool 22-32 cm^3/g (PBR) and crimpy wool 30-36 cm^3/g (SBR) (Elliott 1986). Few research reports quote resilience figures, probably because of the high correlation (which ranges from 0.8 to 0.95 (Elgabbas 1986)) between loose wool bulk and resilience.

Differences in loose wool bulk of approximately 15% will produce detectable differences in yarn bulk (Carnaby & Elliott 1980). Premiums for the higher bulk down-type wools (30-36 cm^3/g) from the SBR ewes arise from use of these in wool-filled quilted products where high bulk and, as a consequence high crimp frequency, are an essential property for these products. This results in maintenance of loftiness and resistance to felting and fibre migration which lead to matting down.

These high bulk wools can also be used in specialist knitwear and tweed products where bulkiness is a keenly sought-after trait (Elliott 1986).

Poll Dorset cross wool may also obtain a premium for bulk (loose wool bulk 25-28 cm^3/g) if it is sought after by the high-value semi-worsted knitwear trade or as a bulk-blend component for carpets. However, Elliott (1984) indicated that, for Perendale wool with loose wool bulk between 25 and 30 cm^3/g, price premiums for bulk alone were neither large enough nor consistent enough (compared to other variables such as fibre fineness or staple length) to warrant the extra cost of measurement. The BR wool (19-24 cm^3/g) is within the region where the differences in loose wool bulk values are of secondary consideration for the majority of manufacturers (Elliott 1986).

No ewe-cross differences existed for any of the CIE values on d 175 but on d 392 the SBR wool was yellower than either the PBR or BR wools (ie higher Y-Z value). The crimpy nature of the Suffolk cross wool, and the openness of the fleece along the midline of the back (which allows increased water penetration and hence a possibly higher incidence of bacterial or fungal infestation) could be a possible cause of increased yellowing of the SBR ewe fleeces.

The Y-Z values for the BR wool agree with the values published by Baker *et al.* (1987) and Bigham *et al.* (1983a) but are considerably lower than those recorded by Bigham *et al.* (1984b). However, their experiments were conducted under much wetter North Island hill country conditions than existed in this trial.

Policy x Cross Interaction

June-lambing BR ewes had a higher MFD on d 84 and d 121 than PBR or SBR ewes, but there was no effect of ewe cross on MFD in August-lambing ewes. This reflects the higher wool growth, and hence higher MFD, in the June-lambing BR ewes than the PBR or SBR ewes. No other policy x cross interactions existed for the wool traits tensile strength, colour, bulk or resilience. The absence of major policy x cross interaction for wool quality traits suggest that the effects of lambing policy on wool quality traits are not unique to a particular ewe cross.

Financial Implications

This trial has established that June-lambing ewes have a different pattern of wool growth than August-lambing ewes. The increased winter wool growth of lactating June-lambing ewes results in an increased MFD and an associated increase in staple tensile strength when measured at the following October shearing. Wool from June-lambing ewes was brighter and whiter than wool from August-lambing ewes.

The higher wool quality found in June-lambing ewes is likely to improve the classification of their wool by approximately one style grade, equivalent to 8¢/kg (W.R. Regnault, *pers. comm.*). This will alter the financial returns budgeted for each policy in Chapter III, increasing returns from June-lambing ewes by approximately $0.30/ewe.

Differences between the ewe crosses in wool quality traits do exist, although translating these to financial differences probably results in minimal price differentials between the different ewe crosses. The higher tensile strength of wool from the BR ewes is negated by a lower bulk reading when compared with the wool from SBR ewes. The wool of PBR ewes was intermediate between those of the other ewe crosses for all wool quality traits.

The preferred choice for both lambing policies, based on results described in Chapter III was the BR ewe and, when the minimal differences in wool quality observed here are considered, the BR is still the preferred choice of ewe for both lambing policies. The higher wool growth in June-lambing ewes and the absence of any appreciable "winter break" suggest that a late-autumn pre-lamb shearing could be a suitable shearing policy for these ewes. However, an October shearing (post-weaning) would not penalise this group because of the improved wool tensile strength and brighter colour associated with their higher winter-wool growth rates during lactation.

A possible explanation for the increased winter wool production from June-lambing ewes is their increased feeding levels during pregnancy/lactation. The next two chapters will address the issue of feeding levels over pregnancy (Chapter VI) and lactation (Chapter V) in June-lambing ewes. The effect of sward surface height on feed intake and wool production will be studied in an effort to determine the role nutrition plays in the increased winter wool growth rates previously measured in June-lambing ewes.

CHAPTER V

THE EFFECT OF SWARD SURFACE HEIGHT ON HERBAGE INTAKE AND PERFORMANCE OF LACTATING JUNE-LAMBING EWES

ABSTRACT

The effects of sward surface height (SSH) on ewe intake and ewe and lamb performance were studied in lactating June-lambing ewes. Thirty-six 4-year-old Border Leicester x Romney (BR), Poll Dorset x BR (PBR) and Suffolk x BR (SBR) ewes balanced for litter size were assigned, 6 days after the mid-point of lambing (29 June 1989), to one of three SSH treatments replicated twice (six ewes/1 ha paddock). The ewes continuously grazed their allotted paddocks throughout the trial. The mean SSH during the 54 days of the trial were 2.6, 4.4 and 7.8 cm. Herbage organic matter intakes (OMI) were measured using intraruminal chromium controlled release capsules during weeks 3, 4, 7 and 8 of lactation. Ewe OMI was not influenced by SSH during week 3 of lactation. Between weeks 4 and 7 of lactation, ewe OMI increased up to a SSH of 7.8 cm. In week 8 of lactation there was no significant difference in OMI between ewes grazing the 4.4 or 7.8 cm SSH treatments, suggesting maximum intake at this stage of lactation is reached at 4.4 cm SSH. Maximum OMI of 2.6 ± 0.1 and 3.0 ± 0.1 kg OM/ewe/d ($P < 0.05$) were reached in week 4 of lactation on the 4.4 and 7.8 SSH treatments, respectively. Ewes grazing the 2.6 cm swards had a relatively constant OMI intake throughout the trial (range 1.8 ± 0.1 to 2.0 ± 0.1 kg OM/ewe/d). However these ewes lost 10.5 kg of liveweight while ewes on 4.4 and 7.8 cm SSH treatments maintained a constant liveweight. Sward surface height had no effect on ewe midside wool growth rate and mean fibre diameter (measured at day 60 of lactation) or on lamb liveweight gain. Ewe breed cross had no effect on ewe OMI or midside wool growth. Lambs reared by SBR ewes were heavier (20.4 ± 0.5 kg) at day 60 of lactation than lambs reared by PBR (18.7 ± 0.6 kg) or BR (18.4 ± 0.6 kg) ewes ($P < 0.05$). These results suggest

that for June-lambing ewes in good condition (condition score 3.0) a SSH of 4.0 cm should ensure adequate levels of ewe and lamb performance. Ewes on a lower herbage allowance will achieve acceptable lamb weaning weights but at the expense of ewe liveweight loss and possible long term carry-over effects on future production.

INTRODUCTION

Productive performance of grazing ruminants is closely related to herbage intake. For grazing sheep, herbage intake and hence production are determined in part by how much herbage is offered - ie by herbage allowance - and by the intensity of grazing (measured by the post grazing herbage mass). Researchers in New Zealand have historically related ewe liveweight change, wool growth and lamb production to herbage allowance because of the difficulty of obtaining reliable estimates of herbage intake in grazing sheep (Rattray *et al.* 1987).

The measurement of herbage allowance is most useful in management systems involving short grazing periods of 1 to 3 days. Under these circumstances it provides a measure of the daily ration of herbage from a known sward mass, and concurrent herbage growth can be largely ignored (Hodgson 1984). The herbage allowance method is more difficult to use where grazing periods are longer and where herbage growth makes a significant contribution to the herbage supply. On most New Zealand farms continuous stocking is practised for the period from lambing to weaning. Therefore, the herbage allowance method may be only a limited aid to the management of such grazing systems. Sward surface height may provide a more meaningful description of the relationship between animal performance and sward conditions under continuous stocking systems (Hodgson 1981; Hodgson & Maxwell 1984; Hodgson 1986; Webby & Pengelly 1986; Parker & McCutcheon 1992).

A number of trials have indicated that the ewe and her progeny are sensitive to the level of nutrition over the period from birth to weaning (Coop *et al.* 1972; Rattray *et al.* 1982b; Munro & Geenty 1983; Parker & McCutcheon 1992) while others have noted an effect of nutrition (herbage allowance) on wool growth during the lactation period (Sumner 1979; Hawker *et al.* 1982; Parker & McCutcheon 1992). The response to increasing herbage allowance or sward surface height (SSH) is usually curvilinear, with maximum ewe and lamb performance reached at herbage allowances of ca. 6 kg DM/ewe/d (Rattray *et al.* 1982b; Rattray *et al.* 1987) or a SSH of 5-6 cm (Milne *et al.* 1981; Penning & Hooper 1985; Orr *et al.* 1990; Parker & McCutcheon 1992).

Most researchers have assumed that feed requirements for out-of-season lambing ewes are the same as those derived for spring-lambing ewes (Barlow 1986; McCall & Bywater 1987; Hawkins *et al.* 1989). Brookes & Barry (1986), however, attempted to adjust the feed intake figures for a simulated autumn-lambing flock to allow for the decreased efficiency of feed utilization for maintenance and growth, and a concomitant increase in heat losses associated with lactating ewes consuming autumn pasture. The decrease in efficiency of feed utilization in autumn is associated with a reduced level of soluble carbohydrate and an increase in crude protein levels in autumn pasture (Armstrong 1981). However, there are currently no estimates of herbage intake of winter-lambing ewes under New Zealand pastoral conditions and the relationship between sward surface height, herbage intake and production remains unknown for ewes lambing in the winter.

This trial aimed to quantify the relationships between sward surface height, herbage quality, herbage intake and animal performance (ewe liveweight change, wool growth and lamb growth) in lactating June-lambing ewes. An understanding of the effects of herbage allowance (as measured by different sward surface heights) on wool growth was expected to assist in explaining some of the differences in wool growth between June- and August-lambing ewes reported in Chapter IV. Measurement of these relationships is also essential for the design of appropriate grazing management strategies for out-of-season lambing programmes.

MATERIALS AND METHODS

Fifty 4-year-old ewes balanced for pregnancy status and ewe cross were transferred to Massey University's Ruminant Research Unit Haurongo Block from Keeble Farm on 8 June 1989. The ewes, comprising three ewe crosses, namely Border Leicester x Romney (BR), Poll Dorset x BR (PBR) and Suffolk x BR (SBR), had been mated without hormone treatment to Suffolk rams on 29 December 1988. The source of these ewes has been described in Chapter II. The trial commenced 6 days after the mid-point of lambing (lactation day 6 (L6)) on 29 June 1989 when 36 ewes (balanced for cross and litter size) were assigned to three SSH treatments replicated twice (six ewes/1 ha paddock). The ewes grazed their assigned paddock throughout the trial. The paddocks had been prepared over the previous 8 weeks to average SSH of 3.0, 6.0 and 9.0 cm (800, 1200 and 1800 kg/DM/ha) by using buffer stock consisting of 1-year-old heifers and dry ewes. Subsequently, the sward heights were maintained in a steady state by the addition or removal of the cattle, although there was little need for this because the stocking rates chosen (6 ewes/ha) were selected to match herbage growth and animal demand on the basis of historical pasture production records (Hawkins *et al.* 1989).

Fewer than the required number of BR ewes lambed with twins within the prescribed period and four extra SBR ewes with twins were therefore used to balance the treatment replicates for litter size. This resulted in an unbalanced distribution of ewe crosses. Two lambs died (one each of two pairs of twins) on the 3.0 cm SSH treatment. The two ewes and their surviving lambs were replaced by non-trial twin-rearing ewes. The ewes were drenched on L6 with Ivomectin (Merck Sharp & Dohme New Zealand Ltd) and the lambs were drenched with the same product on L49 after a mean strongylate egg count of 350 eggs/g faeces (range 0-1900 eggs/g) was recorded on L41. The infected lambs were evenly distributed between the three SSH treatments. Some lambs showed signs of foot scald during very wet periods of the trial and were treated with formalin (Coopers-Pitman-Moore, New Zealand Ltd).

Pasture Measurements

The height of the predominantly ryegrass (*L. perenne*)/white clover (*T. repens*) swards was measured every 5 days from L6 to L60 using the Hill Farming Research Organisation (HFRO) sward stick (Barthram 1986) and an Ellinbank Pasture Meter (EPM; Earle & McGowan 1979). Fifty readings were taken by each method on the same diagonal path within each paddock.

Herbage mass was estimated by cutting twelve $0.18m^2$ quadrats to ground level in each paddock on L9, L25, L46 and L60. Three cuts were taken from each quarter of the paddocks. Before the quadrats were cut an EPM reading was taken to calibrate the EPM height with herbage mass and derive the regression equation ($y=a + bx$) of EPM herbage mass (y) on herbage height (x). These equations provided a basis for using the EPM to obtain additional estimates of pasture mass using the double sampling technique of O'Sullivan *et al.* (1987). Each quadrat sample was washed to remove soil contamination and dried at 100°C for 48 hours before being weighed to determine dry weight.

Pasture composition (ie the proportions by dry weight of grasses, clover, weeds and dead material) was assessed from a sub-sample of bulked pasture cut adjacent to the quadrats.

Animal Measurements

Unfasted ewe and lamb liveweights were taken on L6, L21, L34, L49 and L60, corresponding to weeks 1, 3, 5, 7 and 9 of lactation. All weighings were recorded within 1 hour of removal of ewes and lambs from pasture. Ewes were condition scored using the 5 point scale of Jefferies (1961) on L21 and L60. Likewise, ultrasonic backfat depth C measurements (Delphi A-mode ultrasound, Auckland) were recorded on the ewes on L21 and L60. The mean value for two (left and right side) readings was used in subsequent analysis (Purchas & Beach 1981). Midside wool growth was measured from samples taken on the right midside of ewes while they lay on a flat surface (Bigham 1974). Initial patch clipping occurred on 8 June (Pregnancy d 136) with a subsequent clipping on 21 August (L60). Clean midside wool weight was estimated using the procedure outlined in Chapter IV and comparisons of wool growth were made on the basis of wool weight per unit of skin area for the sampling period (Short & Chapman 1965). Estimates of mean fibre diameter (MFD) were made on the scoured midside samples using the airflow technique (Ross 1958).

Each ewe was dosed with two intraruminal controlled release capsules (CRC, Captec (NZ) Ltd, Auckland, New Zealand), one on L9 (CRC_1, d=0) and the other on L34 (CRC_2, d=0) to deliver the indigestible faecal marker chromic oxide (Cr_2O_3). Samples of faeces were collected daily for CRC_1, between d 7-12 and d 19-22 of CRC life (corresponding to L13-18 and L25-28) and for CRC_2 between d 7-10 and d 15-20 (corresponding to L41-44 and L50-55). Ewes were penned at 0900 h and sampled per rectum over a 10-15 minute period. Samples were often difficult to collect from ewes grazing the 3.0 cm sward and these ewes were retained in the pens for a further 30 minutes to obtain a second sample. Faecal samples were oven-dried at 70°C for up to 72 hours (to constant weight), then bulked within ewes over the 4-day sampling period on an equal weight basis (0.5 g DM/d). The chromium concentration in the faeces was assessed by atomic absorption spectrophotometry as described by Parker *et al.* (1989). The rate of chromium release from the CRC was assumed to be 139 mg/d, which had been measured by Parker (1990) on the same trial area and for similar pasture conditions.

Faecal output (FO; g/d dry matter (DM) or organic matter (OM)) was estimated by dividing the rate of chromium release from the CRC by the concentration of chromium in the faeces (mg Cr/g DM or OM) . Herbage intake (kg OM/d) was determined by dividing FO by the *in vitro* organic matter indigestibility (1-OMD) of the herbage.

Extrusa samples were collected for *in vitro* herbage digestibility determination in each sward from four mixed-age oesophageal fistulated (OF) wethers. These wethers grazed each paddock at intervals corresponding to the collection of faecal samples. The OF sheep were removed from pasture for 1-2 hours prior to collection. The extrusa samples were divided into two equal sub-samples, one for *in vitro* digestibility analysis and the other for separation to determine botanical composition of the diet. Extrusa samples were immediately placed in crushed ice and stored at -12°C until required for analysis. Samples were freeze dried and then ground through a 1.0 mm sieve in preparation for *in vitro* digestibility determination using the cellulase incubation method described by Roughan & Holland (1977). Samples were calibrated against six standards of known *in vivo* OMD values ranging from 0.65 to 0.80 to derive OMD and digestible organic matter in the dry matter (DOMD).

Individual sheep extrusa samples destined for botanical composition analysis were thawed and then separated into grass, clover, weed and dead material following the technique described by Clark & Hodgson (1986). Extrusa samples were floated in a white tray marked into 100 x 1 cm^2 quadrats and point counts of the herbage component appearing over each square intersect were made. These were expressed as a percentage of the total number of counts.

Statistical Analysis

Pasture measurements were subjected to univariate analysis of variance to test for the effects of SSH treatments. As replicates were nested within SSH treatment, the error term used to test the effect of SSH treatment was the SSH treatment x replicate interaction mean square (Snedecor & Cochran 1967). Herbage intake, ewe liveweight, condition score and backfat thickness were analysed using repeated measures analysis (Gill & Hafs 1971). As there was only one measurement of midside wool growth it was analysed using univariate analysis of variance.

The model used was therefore:

$$Y_{ijklm} = \mu + T_i + R_{i(j)} + C_k + L_l + TC_{ik} + TL_{il} + RC_{jk} + RL_{jl} + CL_{kl} + TCL_{ikl} + RCL_{jkl} + e_{ijklm}$$

(Model 5.1)

where

Y_{ijklm} = an observation on the *m*th ewe of the *ith* SSH treatment, the *j*th replicate, the *k*th cross and the *l*th litter size

μ = the general mean

T_i = the fixed effect of the *i*th SSH treatment ($i=1...3$)

$R_{i(j)}$ = the effect of the *j*th replicate nested within the *i*th SSH treatment ($j=1$ or 2)

C_k = the fixed effect of the *k*th cross ($k=1...3$)

L_l = the fixed effect of the *l*th litter size ($l=1$ or 2)

TC_{ik} = the interaction of the *i*th SSH treatment with the *k*th cross

TL_{il} = the interaction of the *i*th SSH treatment with the *l*th litter size

RC_{jk} = the interaction of the *j*th replicate with the *k*th cross

RL_{jl} = the interaction of the *j*th replicate with the *l*th litter size

CL_{kl} = the interaction of the *k*th cross with the *l*th litter size

TCL_{ikl} = the interaction of the *i*th SSH treatment with the *k*th cross and the *l*th litter size

RCL_{jkl} = the interaction of the *j*th replicate with the *k*th cross and the *l*th litter size

e_{ijklm} = the random residual associated with an observation on the *m*th ewe of the *i*th SSH treatment, the *j*th replicate, the *k*th cross and the *l*th litter size

For the analysis of lamb liveweight, lamb sex and birth weight, (fitted as an additional main effect and covariate respectively) were added to Model 5.1

Interaction terms that were not significant ($P>0.05$) were deleted from the model. Differences between group means were tested according to pre-planned comparisons using *t*-tests (Snedecor & Cochran 1967). Data were expressed in terms of means (±SEM). All data were analysed using the Statistical Analysis System computer package (SAS 1985).

RESULTS

Pasture Measurements

The mean sward surface heights (measured by the HFRO sward stick) for the three SSH treatments were 2.6, 4.4 and 7.8 cm ($P<0.001$, Table 5.1). These SSH correspond to herbage masses of 1205, 1837 and 3739 kg DM/ha (Table 5.1). Hereafter, the three swards are referred to by their mean SSH. Sward surface height decreased over the 54 days of the trial, but the differences between SSH treatments were largely maintained (Figure 5.1). The EPM compressed sward height readings followed a similar trend to those of the HFRO sward stick readings (Figure 5.1). There was a significant SSH treatment x time of harvest interaction for herbage mass, but the ranking of SSH treatments did not change. On the 2.6 cm sward, herbage mass varied little throughout the trial (1189 to 1500 kg DM/ha, Table 5.2) whereas for the 4.4 cm sward there was a decrease in herbage mass at L25 and L46 but by L60 herbage mass on this treatment was the same as that at the start of the trial (L9). By contrast, the 7.8 cm sward declined in herbage mass from 4774 kg DM/ha on L9 to 3205 kg DM/ha on L60. Temporal changes in herbage organic matter mass were similar to those for herbage mass (Table 5.2).

There were no significant differences between the SSH treatments in botanical composition of either the cut herbage samples or the extrusa samples collected from OF sheep (Table 5.1). However, there was a trend for the proportion of dead material to be higher and the proportion of clover to be lower in the 7.8 cm sward compared with the 2.6 or 4.4 cm swards. Organic matter digestibility (OMD) was significantly ($P<0.05$) higher in the 2.6 cm sward than in the 4.4 or 7.6 cm swards. Likewise, the ash content was higher ($P<0.05$) in the 2.6 cm than in the 4.4 cm sward which in turn had a higher ash content than the 7.8 cm sward (Table 5.1). There were no differences between the SSH treatments for the digestible organic matter in the dry matter (DOMD) (Table 5.1).

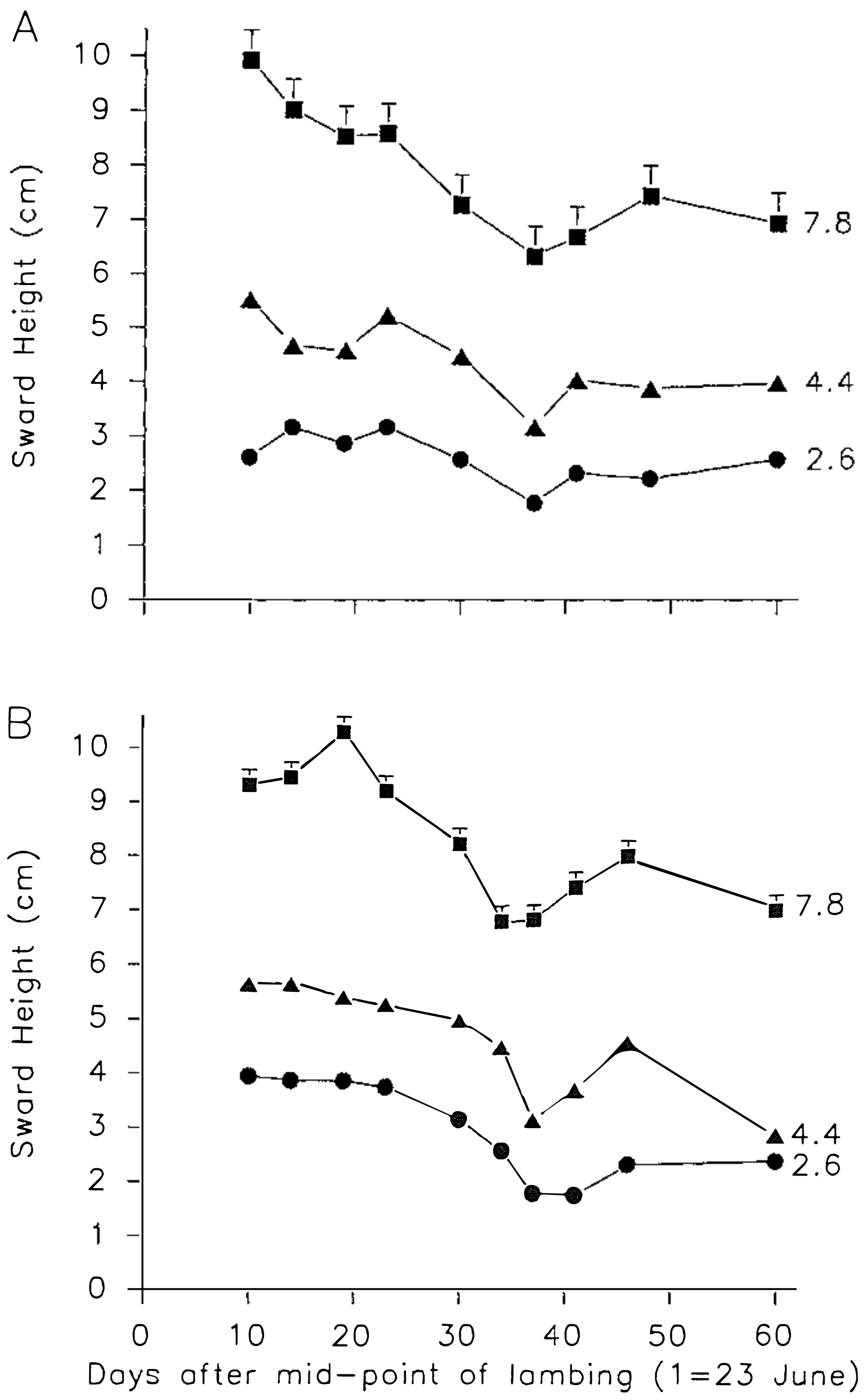


Figure 5.1 **Mean weekly HFRO sward stick green leaf contact heights (A) and Ellinbank Pasture Meter heights (B) for the 2.6 (•), 4.4 (▲) and 7.8 (■) cm sward surface height treatments. (Pooled SE shown on 7.8 cm sward means).**

Table 5.1 Sward height, herbage mass, botanical composition and *in vitro* digestibility of pastures prepared to three sward surface heights (Means and pooled SE).

	Nominal Sward Surface Height (cm)			Pooled SE
	3.0	6.0	9.0	
Sward Height (cm)				
HFRO Sward Stick	2.6[a]	4.4[b]	7.8[c]	0.2
EPM[1]	2.9[a]	4.4[b]	8.1[c]	0.2
Herbage Mass (kgDM/ha)	1205[a]	1837[b]	3739[c]	88
Botanical Composition				
Cut Herbage[2]				
Grass	0.78	0.81	0.79	0.02
Clover	0.03	0.04	0.02	0.01
Weed	0.03	0.02	0.01	0.01
Dead Material	0.16	0.13	0.18	0.02
Extrusa[3]				
Grass	0.78	0.80	0.78	0.02
Clover	0.04	0.04	0.02	0.01
Weed	0.02	0.01	0.00	0.01
Dead Material	0.16	0.15	0.20	0.01
***In vitro* Digestibility**[2]				
OMD	0.824[b]	0.805[a]	0.802[a]	0.007
DOMD	0.673	0.679	0.689	0.007
Ash	0.223[c]	0.177[b]	0.158[a]	0.006

[1] Ellinbank Plate Meter.
[2] Expressed as a proportion of total dry matter.
[3] Expressed as % occurrence by point analysis (see Materials and Methods).
[abc] Means within rows having superscripts with letters in common are not significantly different (P>0.05).

Table 5.2 Herbage mass and organic matter mass on each of three swards at four harvest dates (Mean ± SEM).

	Harvest Date			
	L9[1]	L25	L46	L60
Herbage Mass (kgDM/ha)				
2.6	1189 ± 134	1143 ± 164	989 ± 233	1500 ± 233
4.4	2162 ± 134[b]	1479 ± 164[a]	1559 ± 233[a]	2146 ± 233[b]
7.8	4774 ± 134[c]	2885 ± 164[a]	4091 ± 233[b]	3205 ± 233[a]
Organic Mass (kgOM/ha)				
2.6	919 ± 112	884 ± 137	772 ± 194	1149 ± 194
4.4	1810 ± 112[b]	1204 ± 137[a]	1282 ± 194[a]	1764 ± 194[b]
7.8	4139 ± 112[c]	2432 ± 137[a]	3363 ± 194[b]	2705 ± 194[a]

[1] L9 = Lactation d 9 where L1 = 23 June.

[abc] Means within rows having superscripts with letters in common are not significantly different (P > 0.05).

Ewe Liveweight and Condition

At L6, ewes on the three SSH treatments had similar liveweights but by L60 the liveweights of ewes on the 2.6 cm sward were significantly (P < 0.05) lower than those of ewes on the 4.4 and 7.8 cm swards (Table 5.3). The total liveweight loss from L6 to L60 was 10.5 kg, 2.6 kg and 1.2 kg for the 2.6, 4.4 and 7.8 cm swards, respectively. Ewe cross and litter size had no effect on ewe liveweight on any of the weighing dates.

Table 5.3 Effect of sward height, cross and litter size on ewe liveweight at five periods during lactation (Mean±SEM).

	No.	Liveweight (kg)				
		L6[1]	L21	L34	L49	L60
Sward Height (cm)						
2.6	10	62.5±1.9	59.8±2.4	56.3±2.0[a]	55.0±1.9[a]	52.0±1.8[a]
4.4	12	64.6±1.7	65.1±2.0	64.4±1.8[b]	63.5±1.7[b]	62.0±1.6[b]
7.8	12	64.5±1.7	65.8±2.0	65.7±1.8[b]	64.8±1.7[b]	63.3±1.6[b]
Cross[2]						
BR	9	66.1±2.0	65.4±2.5	64.1±2.1	62.9±2.0	60.9±1.7
PBR	11	61.2±1.8	61.2±2.2	59.8±1.8	58.9±1.8	57.1±1.9
SBR	14	64.3±1.6	64.1±2.0	62.3±1.7	61.6±1.6	59.3±1.5
Litter Size						
1	18	63.7±1.3	63.8±1.7	62.6±1.4	61.5±1.4	59.6±1.3
2	16	64.1±1.5	63.3±1.9	61.6±1.6	60.7±1.5	58.5±1.4
Overall Mean	34	63.8±1.0	63.7±1.2	62.2±1.0	61.2±1.0	59.2±0.9

[1] L6 = Lactation d 6 where L1 = 23 June.
[2] BR=Border Leicester x Romney, PBR=Poll Dorset x BR, SBR=Suffolk x BR.
[ab] Means within main effects and columns having superscripts with letters in common are not significantly different (P>0.05).

Ewe condition scores and ultrasonic backfat measurements tended to decrease (although not significantly) from L21 to L60 on the 2.6 cm sward but not on the 4.4 or 7.8 cm swards (Table 5.4). There were no significant differences between the ewe crosses in condition score or backfat thickness, but the trend was for BR ewes to have lower condition scores and backfat thickness measurements than PBR or SBR ewes at L21 and L60. Single-rearing ewes had a significantly higher condition score (P<0.05) and backfat thickness (P<0.05) than twin-rearing ewes (Table 5.4). All interactions between main effects for ewe liveweight and condition score were non-significant.

Table 5.4 Effect of sward height, cross and litter size on ewe condition score and ultrasonic backfat depth measured on d 21 and d 60 of lactation (Mean±SEM).

	No.	Condition Score[1]		Backfat depth (mm)	
		L21[2]	L60	L21	L60
Sward Height (cm)					
2.6	10	2.8±0.2	2.3±0.2	4.1±0.6	2.4±0.7
4.4	12	2.9±0.2	2.9±0.1	3.5±0.5	4.0±0.5
7.8	12	3.0±0.2	3.1±0.1	4.0±0.5	4.0±0.6
Cross[3]					
BR	9	2.7±0.2	2.5±0.2	3.6±0.6	2.5±0.6
PBR	11	2.9±0.2	2.9±0.2	4.1±0.5	3.5±0.6
SBR	14	3.2±0.1	2.9±0.2	4.1±0.5	3.6±0.5
Litter Size					
1	18	3.2±0.1[b]	3.1±0.1[b]	4.5±0.4[b]	4.3±0.4[b]
2	16	2.6±0.2[a]	2.5±0.1[a]	3.1±0.5[a]	2.1±0.5[a]
Overall Mean	34	3.0±0.1	2.8±0.1	3.9±0.3	3.4±0.3

[1] Condition Score using 10 x 0.5 scale (Jefferies 1961).
[2] L21 = Lactation d 21 where L1 = 23 June.
[3] BR=Border Leicester x Romney, PBR=Poll Dorset x BR, SBR=Suffolk x BR.
[ab] Means within main effects and columns having superscripts with letters in common are not significantly different (P>0.05).

Ewe Intake

Ewes grazing the 2.6 cm SSH treatment had lower OMI than the ewes on the 4.4 and 7.8 cm SSH treatments (Table 5.5). There was a significant ($P<0.05$) SSH treatment x time interaction which reflected the fact that the magnitude of differences in ewe OMI between the three swards varied throughout the trial. Early in lactation (L13-L18), there was no significant difference between the three swards in ewe OMI but in the period L25-L28 the ewes on 2.6 cm sward had significantly ($P<0.05$) lower OMI than ewes on either the 4.4 or 7.8 cm swards. During week 7 of lactation

(L41-L44) the ewes on the 7.8 cm sward had higher OMI than ewes on either the 2.6 and 4.4 cm swards. There was no different in OMI for ewes grazing these latter two swards during this period. From L50-L55 the ewes grazing the 2.6 cm SSH treatment had the lowest OMI intakes while there was no difference in OMI between ewes grazing the 4.4 or 7.8 cm SSH treatments.

Ewe cross had no effect on ewe OMI at any of the four sampling periods. Twin-rearing ewes had significantly ($P<0.05$) higher OMI from L13-18 but there was no effect of litter size on ewe OMI in any of the subsequent sampling periods (Table 5.5). There were no significant interactions for OMI between any of the main effects.

Table 5.5 Effect of sward height, cross and litter size on ewe organic matter intake at four periods during lactation (Mean± SEM).

	No.	Organic Matter Intake (kg OM/ewe/d)			
		L13-L18[1]	L25-L28	L41-L44	L50-L55
Sward Height (cm)					
2.6	10	2.0±0.1	1.9±0.1[a]	1.8±0.2[a]	1.8±0.1[a]
4.4	11	2.3±0.1	2.6±0.1[b]	1.9±0.2[a]	2.3±0.1[b]
7.8	11	2.3±0.1	3.0±0.1[c]	2.6±0.2[b]	2.1±0.1[b]
Cross[2]					
BR	9	2.2±0.2	2.4±0.1	2.1±0.2	2.1±0.1
PBR	10	2.3±0.1	2.7±0.1	2.0±0.2	2.0±0.1
SBR	13	2.3±0.1	2.4±0.1	2.2±0.1	2.1±0.1
Litter Size					
1	16	2.0±0.1[a]	2.4±0.1	2.0±0.1	2.0±0.1
2	16	2.5±0.1[b]	2.6±0.1	2.2±0.1	2.1±0.1
Overall Mean	32	2.2±0.1	2.5±0.1	2.1±0.1	2.0±0.1

[1] L13-L18 refers to lactation d 13 to d 18 where L1=23 June.

[2] BR=Border Leicester x Romney, PBR=Poll Dorset x BR, SBR=Suffolk x BR.

[abc] Means within main effects and columns having superscripts with letters in common are not significantly different ($P>0.05$).

Wool Production

Sward surface height, ewe cross and litter size had no effect on ewe midside wool growth or mean fibre diameter (MFD) throughout the trial (Table 5.6). There was a trend, however, for the BR ewes to produce more midside wool than PBR or SBR ewes.

Table 5.6 Effect of sward height, cross and litter size on clean midside wool growth from d 136 of pregnancy to d 60 of lactation and on the mean fibre diameter of wool grown in this period. (Mean ± SEM).

	No.	Wool Growth ($\mu g/cm^2/day$)	MFD[1] (μm)
Sward Height (cm)			
2.6	10	621 ± 58	35.7 ± 0.8
4.4	12	577 ± 52	38.2 ± 0.7
7.8	12	528 ± 53	37.3 ± 0.7
Cross[2]			
BR	9	650 ± 61	37.7 ± 0.8
PBR	11	558 ± 54	36.2 ± 0.7
SBR	14	520 ± 49	37.1 ± 0.6
Litter Size			
1	18	537 ± 41	37.5 ± 0.5
2	16	614 ± 48	36.5 ± 0.6
Overall Mean	34	553 ± 30	37.0 ± 0.4

[1] Mean fibre diameter.
[2] BR = Border Leicester x Romney, PBR = Poll Dorset x BR, SBR = Suffolk x BR.

Lamb Production

Lambs grazing the 2.6 cm sward tended to be lighter at each of the weighing periods (Table 5.7). The difference, although not statistically significant, was 1.8 kg between lambs reared on the 2.6 cm v. 7.8 cm SSH treatments at the end of the trial (L60).

At L6, a significant ($P<0.01$) SSH treatment x damcross interaction was apparent with respect to lamb liveweight. There was no ewe cross effect on lamb liveweight on the 2.6 cm sward whereas PBR ewes had heavier lambs than SBR or BR ewes on the 4.4 cm sward and SBR ewes had heavier lambs than BR or PBR ewes on the 7.8 cm sward.

At L21, ewe cross had no effect on lamb liveweight on the 2.6 or 4.4 cm swards but on the 7.8 cm sward lambs reared by SBR ewes were heavier than those reared by PBR or BR ewes (significant SSH treatment x damcross interaction, $P<0.05$). Ewe cross had no effect on lamb liveweight at L34. At L49 and L60, lambs reared by SBR ewes were heavier than lambs reared by PBR or BR ewes. There was no difference between lambs reared by PBR or BR ewes at L49 or L60, nor any significant interactions with SSH treatment at these weighing periods. Single-reared lambs were heavier than twin-reared lambs at every weighing (Table 5.7). Male lambs were lighter at L6 but by the end of the trial (L60) they were 1.5 kg heavier than female lambs (19.9 ± 0.5 kg v. 18.4 ± 0.5 kg, $P<0.10$).

Table 5.7 Effect of sward height, damcross, litter size and sex of lamb on lamb liveweight at five periods during lactation (Mean ± SEM).

	No.	Liveweight				
		L6[1]	L21	L34	L49	L60
Sward Height (cm)						
2.6	14	6.1 ± 0.3	10.3 ± 0.3	13.0 ± 0.5	15.9 ± 0.6	18.1 ± 0.7
4.4	18	7.1 ± 0.3	11.3 ± 0.3	14.3 ± 0.4	17.3 ± 0.6	19.6 ± 0.5
7.8	18	6.5 ± 0.3	10.8 ± 0.3	14.0 ± 0.5	17.6 ± 0.6	19.9 ± 0.6
Damcross[2]						
BR	14	5.8 ± 0.3	10.3 ± 0.3	13.4 ± 0.5	16.7 ± 0.7^a	18.4 ± 0.6^a
PBR	16	7.0 ± 0.3	10.7 ± 0.4	13.5 ± 0.5	16.1 ± 0.7^a	18.7 ± 0.6^a
SBR	20	6.9 ± 0.3	11.3 ± 0.3	14.3 ± 0.4	18.1 ± 0.5^b	20.4 ± 0.5^b
Litter Size						
1	18	6.8 ± 0.3	11.5 ± 0.3^b	14.6 ± 0.5^b	18.0 ± 0.6^b	20.3 ± 0.6^b
2	32	6.4 ± 0.2	10.1 ± 0.2^a	12.9 ± 0.4^a	16.0 ± 0.5^a	18.1 ± 0.5^a
Sex						
Female	21	6.7 ± 0.3	10.6 ± 0.3	13.4 ± 0.4	16.6 ± 0.5	18.4 ± 0.5
Male	29	6.4 ± 0.3	11.0 ± 0.3	14.1 ± 0.4	17.3 ± 0.5	19.9 ± 0.5
Overall Mean	50	6.6 ± 0.1	10.8 ± 0.2	13.7 ± 0.2	17.0 ± 0.3	19.1 ± 0.3

[1] L6 = d 6 of lactation where L1 = 23 June.
[2] BR = Border Leicester x Romney, PBR = Poll Dorset x BR, SBR = Suffolk x BR.
[ab] Means within main effects having superscripts with letters in common are not significantly different (P > 0.05).

DISCUSSION

The objective of this trial was to quantify the relationships between sward surface height, herbage intake and animal performance in lactating June-lambing ewes. These relationships were considered essential to assist in the design of appropriate grazing management strategies for out-of-season lambing ewes.

Paddocks were initially prepared to nominal sward heights of 3.0, 6.0 and 9.0 cm. The actual mean sward heights were 2.6, 4.4 and 7.8 cm respectively. Throughout the 54 days of the trial, SSH declined from 9.9 cm to 6.9 cm on the "9.0 cm" sward, from 5.5 cm to 3.9 cm on the "6.0 cm" sward, and was relatively constant on the "3.0 cm" sward. This indicates that the stocking rate, although conservatively chosen to match previously recorded pasture growth rates (Hawkins *et al.* 1989) with expected animal intakes, was too high with the result that ewe intakes exceeded net pasture growth. The greater ewe OMI actually measured, compared with those originally predicted (see later), contributed to the decline in SSH. Furthermore, the herbage accumulated during the pre-trial period, while the nominally 6.0 and 9.0 cm swards were being prepared, may have begun to decay over the June-July period thereby promoting a negative net herbage accumulation rate (Hodgson & Maxwell 1984). A marginally higher proportion of dead material on the 7.8 cm SSH treatment compared with the 4.4 and 2.6 cm SSH treatments supports this latter explanation. However, pasture quality on all the SSH treatments was similar to that of good quality spring pasture (predicted range 10.7 - 11.0 MJ ME/kg DM using the equation of Geenty & Rattray (1987) where ME = 0.16 DOMD) and therefore poor herbage quality was not an obvious constraint to intake.

Animal Intake

Ewe organic matter intakes varied with SSH according to the stage of lactation. Between L13 and L18 there was no effect of SSH on ewe OMI whereas, at L25 to L28 and L41 to L44, there was a greater OMI in ewes grazing the 7.8 cm SSH treatment. At L50 to L55, maximum ewe intakes were reached at a SSH of 4.4 cm. These results suggest that the SSH required for maximum ewe intakes will vary according to the stage of lactation. The period L25 to L44 coincides with the period of maximum milk production in ewes (Wallace 1948; Coop *et al.* 1972; Gibb & Treacher 1982; Geenty 1983; Treacher 1983) and therefore with the period when ewes require maximum herbage intake to meet the increased energy demands of lactation. This probably explains the increased ewe OMI over the range 2.6-7.8 cm and possibly beyond the range of SSH measured in this trial. The likely explanation for the lack of a SSH effect on ewe OMI during the period L13 to L18, coinciding with weeks 2 and 3 of lactation, is that ewes were mobilizing body tissue to meet the demands of lactation. In addition, there is likely to be a time lag between increased requirements needed by the lactating ewe and the physical process of increasing herbage intake to meet these requirements. Utilisation of body tissue during the initial 4-6 weeks of lactation has been noted by many researchers (Peart 1970; Coop *et al.* 1972; Jagusch *et al.* 1972; Cowan *et al.* 1979; Cowan *et al.* 1980; Gibb & Treacher 1980; Geenty & Sykes 1986). Another explanation for the lack of a SSH effect on ewe OMI in early lactation is a lower energy demand because milk intake by the smaller and younger lambs is relatively low, compared to the demand later in lactation.

Once ewes have reached their peak lactation (usually weeks 5-6 of lactation) the nutrient demand of the udder declines and lambs begin consuming small amounts of herbage. This is reflected in the general pattern of OMI across time (particularly among ewes on the 7.8 cm sward whose intakes peaked at L25-L44). The declining demand may also explain the lack of difference in OMI between ewes on the 4.4 and 7.8 cm swards at L50-L55.

There have been several trials relating SSH to herbage intake in spring-lambing ewes. Parker & McCutcheon (1992) found that intakes were maximised at a SSH of 5 cm. Their trial was located on the same paddocks and with ewes of similar liveweight to those in the trial reported here. Other researchers have also noted that ewe intake is maximised at a sward surface height of around 6 cm (Penning & Hooper 1985; Foot *et al.* 1987; Orr *et al.* 1990; Penning *et al.* 1991; Chestnutt 1992). The current research findings agree with the 3-6 cm target SSH recommended for ewes grazing at pasture under continuous stocking management (Hodgson *et al.* 1986; Maxwell & Treacher 1987), targets which have been derived exclusively from spring-lambing ewes. Recent reports suggest that lamb growth rates in early lactation may in fact increase up to a SSH of 9.0 cm (Orr *et al.* 1990; Chestnutt 1992). Most researchers have considered it undesirable to have ryegrass-dominant swards at a SSH of 9.0 cm during spring because at these heights pasture quality may deteriorate as the ryegrass plants enter the reproductive growth phase. However this is not a concern for winter-lactating ewes, and ewe intakes may increase with SSH greater than the 7.8 cm studied in the trial reported here. The issue is further complicated by the fact that pasture growth rates are generally declining during lactation for autumn/winter-lambing ewes. This requires a relatively low stocking rate if SSH are to be maintained above the 4-6 cm usually recommended for spring-lambing ewes. The data from this trial support the case for set-stocking at lambing initially at a relatively high stocking rate (when ewe intakes are less sensitive to SSH) and then reallocation at a lower stocking rate later in lactation when intake and requirements are greater.

Maximum ewe intakes were reached during week 4 of lactation on the 4.4 and 7.8 cm SSH treatments, whereas ewes grazing the 2.6 cm SSH treatment had relatively constant intakes throughout the trial. The maximum ewe OMI of 2.6±0.1 and 3.0±0.1 kg OM/ewe/d measured on the 4.4 and 7.8 cm SSH treatments correspond to a calculated DMI of 3.1 and 3.5 kg DM/ewe/d (this includes soil ingestion) and energy intakes of 34.3 and 38.7 MJME/ewe/d (for DOMI see Appendix I). These predicted energy intakes are 10% greater than those suggested by Geenty & Rattray (1987) for ewes at this stage of lactation. Those authors calculated that the requirements for 65 kg ewes suckling a single lamb or twin lambs during week 3 of lactation were 31.0 MJME/ewe/d and 35.0 MJME/ewe/d, respectively. Ewes grazing the 2.6 cm SSH treatment had a maximum intake of 2.0±0.1 kg OM/ewe/d (2.3 kg DM/ewe/d or 25 MJME/ewe/d) which is 17 and 26% below the recommended daily requirements for single- and twin-rearing ewes suggested by Geenty & Rattray (1987).

The predicted intakes measured in this trial are somewhat higher than those recorded by Parker & McCutcheon (1992) who found that, on 5 and 7 cm sward heights, maximum ewe intakes of 2.17 and 2.31 kg OM/ewe/d were not reached until week 7-8 of lactation. The ewes in the trial reported by Parker & McCutcheon (1992) were approximately 8 kg lighter than ewes in this trial which probably accounts for the greater intakes measured in the trial reported here. Vulich *et al.* (1991)

also recorded maximum ewe intakes of 2.9 kg OM/ewe/d during weeks 6 and 7 of lactation. Other researchers have noted that peak intake in ewes is not reached until the second month of lactation (Hadjipieris & Holmes 1966; Gibb & Treacher 1980; Gibb & Treacher 1982; Orr *et al.* 1990). In contrast, others have found (like the trial reported here) that peak ewe intakes occurred during week 4 of lactation (Gibb *et al.* 1981). These differences between experiments are to be expected as there is likely to be an interaction between herbage allowance, ewe condition, environmental conditions and time of maximum ewe intake during lactation. Gibb *et al.* (1981) noted that this occurred in their trial, with ewes on a low allowance reaching maximum intakes in week 5 of lactation, while those on a high allowance reached their maximum intakes in week 3 of lactation.

Ewe breed cross had no effect on OMI intake. Vulich *et al.* (1990) found that adult ewes from breeds of a large mature size had higher intakes per unit of body weight than ewes from breeds of a small mature size. There are, however, relatively few measurements on the effect of ewe breed on herbage intake at pasture. Despite the absence of data from the literature it is reasonable to assume that herbage intakes will be similar among ewe breeds or crosses of a similar liveweight such as those studied in this experiment.

The ewes on the 2.6 cm SSH in this trial lost 0.5 condition score units or 1.5 mm of backfat from L21 to L60. These same ewes were losing approximately 200 g/d throughout the period L10 to L60 which suggests that, at a SSH of less than 3 cm, lactating ewes are unable to consume sufficient quantities of herbage to satisfy their requirements. To compensate for such feeding levels, ewes in a good body condition (like those in this trial) will mobilize body reserves (and hence lose liveweight) to maintain milk production while ewes in a poor condition or of a low liveweight will have a depressed milk production and hence their lambs will have slower growth rates (Gibb & Treacher 1980; Geenty & Sykes 1986). The latter scenario will also result in depressed ewe wool production and lowered future reproductive potential especially in situations where feed is limited over the summer period. However with autumn/winter-lambing ewes this may be less important as some loss of condition or liveweight can be tolerated, provided lamb growth rates are maintained, because the period of maximum pasture growth (spring) can be utilised to recover body condition before the next mating period.

Twin-rearing ewes had 25% higher intakes than single-rearing ewes during week 3 of lactation. However, in weeks 4, 7 and 8 of lactation, litter size had only a small (5-10%) and non-significant effect on ewe intake. The single-rearing ewes apparently diverted more of their energy intake to fat deposition as reflected in their higher condition scores and backfat levels compared to twin-rearing ewes. Alternatively twin-rearing ewes may have mobilized more tissue to support their higher lactation requirements. This small but consistent increase in OMI recorded in twin-rearing ewes during week 4, 7 and 8 of lactation is considerably less than the 20-30% suggested by Coop & Drew (1963) and Geenty & Sykes (1986). It does, however, agree with the results of Parker & McCutcheon (1992) who recorded a 1-18% increase in intake for twin-rearing ewes over single-rearing ewes in the first 9 weeks of lactation. Other researchers have also noted small differences in herbage intake for ewes suckling single v. twin lambs (Rattray & Jagusch 1978; Maxwell *et al.* 1979; Newton & Orr 1981; Gibb & Treacher 1982; McEwan *et al.* 1983; Parker *et al.* 1991). In contrast to these results some trials have shown consistently, even if not significantly, higher intakes by twin-rearing ewes compared with single-rearing ewes when fed pelleted rations indoors (Hadjipieris & Holmes 1966; Peart 1968; Peart *et al.* 1979).

Wool Production

The negligible effect of SSH treatment on midside wool growth during lactation is consistent with other research results (Allden 1979; Geenty & Sykes 1986; Parker & McCutcheon 1992). Hawker *et al.* (1982) noted that between an allowance of 2 and 10 kg DM/ewe/d there was only a small difference (0.15 ± 0.05 kg) in wool growth during lactation. Rattray *et al.* (1982b), however, suggested that very high pasture allowances, ie above 8 kg DM/ewe/d, may increase wool growth.

The lack of a wool growth response to increasing SSH in the trial reported here may also be related to an "emergence time" lag of between 5 and 20 days before a change in wool growth can be measured above the skin (Rattray *et al.* 1987).

The lack of a significant effect of ewe breed cross on midside wool growth is contrary to the finding in Chapter IV where BR ewes had higher midside wool growth rates during lactation than either PBR or SBR ewes. However the trends were similar in this study and insufficient numbers of ewes within each cross may have contributed to the lack of statistical significance.

The minimal effect of litter size on midside wool growth agrees with results from Chapter IV and other research results (Corbett 1979; Parker *et al.* 1991; Parker & McCutcheon 1992). Reduced wool growth is probably greater in twin-rearing ewes when lactation is longer than the 60 days recorded during this trial and also when herbage allowance and feeding level are very low (Allden 1979).

Lamb Production

Sward height had no effect on lamb liveweight gain over the first 60 days of lactation. Parker & McCutcheon (1992) also found that lamb growth was unaffected by SSH especially during the first 45 days of lactation. When ewes are in good condition immediately post-lambing (in the experiment reported here they weighed over 60 kg and had body condition scores of 3.0) they mobilise body reserves to maintain milk production (Peart 1970; Coop *et al.* 1972; Jagusch *et al.* 1972; Gibb & Treacher 1980; Clark *et al.* 1986; Geenty & Sykes 1986). This is the most probable explanation as to why lamb growth rates on the 2.6 cm SSH treatments were similar to those of lambs reared by ewes on the 4.4 and 7.8 cm SSH treatments. Ewes grazing the 2.6 cm SSH treatment weighed the same as ewes on the other treatments at L6 but had lost 10.5 kg (or 0.5 condition score units and 1.5 mm of backfat) by L60 while ewes on 4.4 and 7.8 cm SSH treatments essentially maintained their liveweight and condition.

In contrast to these results several researchers have noted that lamb growth increases with increasing herbage allowance during lactation (Rattray & Jagusch 1978; Rattray *et al.* 1982b). There is also good evidence collected from United Kingdom research institutions that growth rates of spring-born lambs increase as SSH increases from 3 cm to 6 cm (Parsons 1984; Penning 1986; Maxwell & Treacher 1987; Penning *et al.* 1991). Orr *et al.* (1990) and Chestnutt (1992), however, noted that the performance of suckling lambs is sensitive to changes in SSH up to 9 cm, possibly because of a greater opportunity to select more a highly digestable herbage at the higher SSH.

Lambs reared by Suffolk x BR ewes were marginally heavier at the end of the trial than lambs reared by PBR or BR ewes. The respective growth rates from L6 to L60 were 233, 217 and 250 g/d for lambs reared by BR, PBR and SBR ewes and these compare favourably with the 226, 237 and 227 g/d measured for June-born lambs reared by BR, PBR and SBR ewes in Chapter III.

CONCLUSIONS

This trial indicates that, for June-lambing ewes, target sward surface heights that maximise ewe intakes will vary according to the stage of lactation. Ewe and lamb production from birth to day 60 of lactation is maximised at a SSH of 4.0 cm. Ewes in very good condition (condition score 3.0) prior to lambing will maintain lamb growth at low (2-3 cm) sward heights but at the expense of ewe liveweight loss. The herbage intakes measured in this trial indicate that, for feed budgeting purposes, the feed tables calculated for August-lambing ewes are suitable for use in June-lambing ewes. However, on the basis of the results reported here and in the literature there seems little justification for allocating an additional feed allowance for twin-rearing ewes as is indicated in the feed tables. The opportunity exists in June-lambing ewes to use ewe liveweight and condition score as a buffer against very low SSH without causing detrimental effects to long term production. This is because June-lambing ewes have the spring period, when herbage growth usually exceeds animal requirements on most New Zealand sheep farms, to regain the liveweight lost during lactation before the next mating begins in January.

CHAPTER VI

EFFECT OF SWARD HEIGHT DURING LATE PREGNANCY ON INTAKE AND PERFORMANCE OF JUNE- AND AUGUST-LAMBING EWES

ABSTRACT

Herbage organic matter intakes (OMI) were measured, using intraruminal controlled release capsules (CRC), during the last 4 weeks of pregnancy in ewes due to lamb in June (winter) or (August) spring. The relative OMI (averaged across lambing date groups) were 1.4±0.1, 1.7±0.1, 1.7±0.1 and 1.9±0.1 kg OM/ewe/d (mean ±SEM, $P<0.01$) in ewes maintained at a SSH of 2.0, 4.0, 6.0 and 8.0 cm respectively. Ewes that were in a good body condition score achieved their required intakes on SSH maintained at 2.0 cm. Relative to those ewes on the 8.0 cm SSH treatment, ewes on the 2.0, 4.0 and 6.0 cm SSH treatment attempted to increase intake by increasing grazing duration rather than biting rate. Ewe liveweight, condition score, midside wool growth rate and mean fibre diameter were not affected by sward surface height. There was no effect of SSH on lamb birth weight but lambs born in June were lighter than lambs born in August (4.4±0.2 v. 5.3±0.2 kg, $P<0.001$). This trial has shown that, at the same SSH, June-lambing pregnant ewes can achieve similar OMI to those of August-lambing ewes. It is concluded that a target SSH of 2.0 cm is appropriate for both August- and June-lambing ewes in good condition. However, for August-lambing ewes in poor condition a SSH of 2.0 cm during the last month of pregnancy will be detrimental to overall production, particularly in terms of ewe liveweight loss.

INTRODUCTION

Management priorities for the ewe flock during pregnancy include supplying sufficient nutrients to ensure adequate lamb birth weights and to allow for a satisfactory ewe lactation performance. In early- and mid-pregnancy the requirement for nutrients are low and the ewe can therefore be fed at maintenance or even sub-maintenance levels depending on the feed supply available and the ewe condition at that particular time (Smeaton *et al.* 1983; Smeaton & Rattray 1984; Holst *et al.* 1986; Rattray 1986). Ewes in a moderate to good condition can tolerate some liveweight loss and hence sub-maintenance feeding to save pasture for use in late pregnancy or post-lambing (Smeaton *et al.* 1983). During the last 4-6 weeks of pregnancy the nutrient requirements of the pregnant ewe increase curvilinearly and average 1.50 and 1.75 times maintenance for single- and twin-bearing ewes, respectively (Rattray 1986).

A strong relationship between the level of nutrition in late pregnancy and lamb birth weight would therefore be expected (Rattray *et al.* 1974; Russel *et al.* 1977; Robinson 1983). However, the majority of nutritional regimens imposed on ewes during pregnancy under New Zealand pasture feeding conditions have had a minimal effect on lamb birth weight and subsequent growth rate (Coop 1950; Coop & Clark 1969; Monteath 1971; Rattray 1978b; Rattray *et al.* 1982a; Smeaton *et al.* 1983; Smeaton & Rattray 1984; Geenty & Sykes 1986). Maternal body reserves can often compensate for considerable nutritional deprivation in late pregnancy if ewes enter this period in a good body condition (Rattray & Trigg 1979). However if ewes are in poor condition during late pregnancy and are then fed below requirements, detrimental effects on lamb growth rates can be expected (Smeaton *et al.* 1985). This is accentuated when litter size is greater than one.

Restricted intakes during the winter pregnancy period have relatively small effects on ewe wool growth, primarily due to the poor potential for wool growth during winter (Corbett 1979; Rattray *et al.* 1987). However the incidence of tenderness or break increases with intake restriction during the winter (Hawker & Thompson 1987). This might not be the case for lactating June-lambing ewes in which high winter wool growth rates have been measured (Reid *et al.* 1988; Reid & Sumner 1991; Chapter III). Wool growth rates of June-lambing ewes during late pregnancy (ie wool growth rates in April/May) would also be relatively high compared with the low winter wool growth rates measured in pregnant August-lambing ewes (Hawker *et al.* 1982; Parker *et al.* 1991).

There have been few measurements of ewe herbage intake over late pregnancy collected under conditions of continuous stocking in New Zealand. With the exception of Parker *et al.* (1991) most studies have involved rotational stocking systems, where herbage intake was assessed by pre- and post-grazing herbage cuts (Monteath 1971; Rattray *et al.* 1982a; Geenty & Sykes 1986). There are no published estimates from New Zealand studies of herbage intake over a range of herbage allowances or sward surface heights for winter-lambing ewes during pregnancy.

The aim of this experiment was therefore to compare the effect on ewe and lamb production of a range of sward surface heights during the last 4 weeks of pregnancy in June- and August-lambing, single- and twin-bearing ewes. Since sward conditions exert a direct effect upon the grazing parameters intake per bite, rate of biting and grazing duration (Allden & Whittaker 1970; Hodgson 1982), these parameters were also measured to help explain any observed differences in herbage intake. Data from this experiment were also expected to provide information for feed budgeting and modelling studies for out-of-season lamb production systems and to clarify whether the performance of June-lambing ewes is the same as that of August-lambing ewes at similar herbage allowances.

MATERIALS AND METHODS

The trial was located at the Massey University Ruminant Research Unit Haurongo Block. One hundred and ninety 2-year-old and mixed aged (3-year-old to 5-year-old) Border Leicester x Romney ewes were randomly assigned in December 1989 to either a June-lambing policy (110 ewes) or an

August-lambing policy (80 ewes). Mating of the June-lambing ewes commenced on 5 January 1990 and was accomplished using a combination of progesterone-impregnated controlled internal drug releasing devices (CIDR Type G, AHI Plastic Moulding Company, Hamilton, New Zealand), 400 i.u. PMSG (Folligon, Intervet (Australia) Pty Ltd) and high ram:ewe ratios (1:10)(Knight *et al.* 1989b). The August-lambing ewes were mated on 19 March 1990 after synchronisation with CIDRs alone. The average mating weight of June-lambing ewes was 55.5±0.9 (mean±SEM) kg while for the August-lambing ewes it was 56.6±1.0 kg. All ewes were mated to mixed aged Coopworth rams. The mean lambing dates for the two lambing policies were 3 June and 17 August, respectively. Approximately six weeks after ram removal (19 March and 5 June for June- and August-lambers, hereafter referred to pregnancy day 75 or as P75), 48 ewes from each policy, balanced for litter size (as determined by ultrasound pregnancy diagnosis) and ewe age (2-year-old v. mixed aged) were selected for the trial. All ewes were pregnant to the first cycle of mating and had an initial midside patch (ca. 20 x 20 cm) cleared on P75. They were then grazed together within each lambing policy until P115. The 2-year-old ewes were shorn in February while the mixed aged ewes had been shorn the previous November. Ewe feeding from ram removal until P115 was at recommended maintenance levels for 55 kg ewes (Rattray 1986). On P115 ewes from each policy were randomly allocated within age and litter size to one of four sward surface height (SSH) treatments replicated twice (six ewes/1 ha paddock). The four SSH treatments of nominally 2.0, 4.0, 6.0 and 8.0 cm (600, 1000, 1400 and 1800 kg DM/ha) had been prepared over the previous 12 weeks using a non-trial group of ewes. The SSH treatment paddocks were maintained at the prescribed height for four weeks prior to the commencement of intake measurements. The ewes grazed their respective SSH treatment from P115 to P140 after which they were set-stocked for lambing on to swards with a SSH of 4.0 cm. Throughout the late pregnancy period (P115-P140) paddocks were maintained as close as possible to the required SSH by the addition of non-trial buffer stock, in this case rising 1-year-old heifers.

Lambs were weighed and tagged at birth, and identified to their dam. All ewes were drenched on P115 with Ivermectin liquid (Merck Sharp & Dohme New Zealand Ltd) while lambs were drenched with Levamisole (Nilverm, Coopers-Pitman-Moore, New Zealand Ltd) on L54. One ewe from the June-lambing group aborted on P125 and was replaced by another single-bearing ewe. Three ewes from each lambing policy failed to lamb and were excluded from the trial. Ewes that failed to rear one of a pair of twin lambs were classified as "litter size = two" for pre-lambing measurements and as "litter size = one" for post-lambing measurements. There were eight June-lambing ewes and six August-lambing ewes in this category.

Pasture Measurements

Sward surface height was measured every 5 days from P115 to P140 using the Hill Farming Research Organisation (HFRO) sward stick (Barthram 1986) and an Ellinbank Pasture Meter (EPM; Earle & McGowan 1979). Fifty readings were taken on the same diagonal path within each SSH treatment. Herbage mass was estimated by cutting twelve 0.18m^2 quadrats to ground level in each paddock on P115 and P139. Before each quadrat was cut, an EPM reading was taken to calibrate the EPM against herbage mass and therefore to derive additional estimates of pasture mass between the herbage cuts of P115 and P139. Herbage samples were washed to remove soil contamination, dried at 100°C for 48 hours and weighed to determine dry weight. A sample of herbage was cut adjacent to each quadrat, bulked within each replicate and then sub-sampled to determine pasture composition.

Animal Measurements

Liveweights of ewes were recorded within 1 hour of their removal from pasture on days P115, P128 and P140, while unfasted ewe and lamb liveweights were taken on days L54 (lactation day 54) and L77. Ewe condition score, using the 5 point scale of Jefferies (1961), and ultrasonic backfat depth C measurements (Delphi A-mode ultrasound, Auckland; Purchas & Beach 1981) were measured on P115, P140 and L77.

Wool samples were clipped from the right midside of ewes on P115, P140 and L77. The first sample (P115) included a period of pre-trial wool growth from the initial midside patch clearance on P75. Clean midside wool weight was estimated (using the same procedure outlined in Chapter IV) to allow comparisons of wool growth on the basis of wool weight per unit of skin area for the sampling period (Short & Chapman 1965). Estimates of mean fibre diameter (MFD) were made on the scoured midside sample taken on L77 using the airflow technique (Ross 1958).

Each ewe was dosed with a single chromic oxide intraruminal controlled release capsule (CRC; Captec (NZ) Ltd, Auckland) on P115 (30 April and 17 July for June- and August-lambing ewes, respectively). Eight days after CRC dosing a 4-day faecal sampling period (P122-P125) commenced. Ewes were sampled over a 15 minute period per rectum after being penned at 0900 h on the day of sampling. A second 4-day sampling period commenced 20 days after CRC insertion (P135-P139). Faecal samples were oven dried at 70°C for up to 72 hours (to constant weight) and then samples were bulked within ewes over the 4-day sampling periods on an equal weight basis (0.5 g DM/d). The chromium concentration in the faeces was assessed by atomic absorption spectrophotometry as described by Parker *et al.* (1989). Faecal output, expressed in terms of organic matter (OM), was divided by the indigestibility of the herbage during each sampling period to determine organic matter intake (OMI, g OM/d).

Four mixed aged oesophageal-fistulated (OF) wethers were rotated around each paddock at intervals corresponding to faecal collection periods in the ewes. Samples of extrusa collected from the wethers were divided into two equal sub-samples, one for *in vitro* digestibility analysis and the other for botanical separation to determine diet composition. After collection, the extrusa was immediately placed on crushed ice and stored at -12°C until analysis. Samples were freeze-dried and then ground through a 1.0 mm sieve before *in vitro* digestibility determination using the cellulase incubation method described by Roughan & Holland (1977).

Botanical composition of the samples of extrusa was determined by washing samples to remove saliva and chlorophyll colouring, floating samples on water and then identifying 100 points per sample over a grid (Clark & Hodgson 1986). Point counts of grass, clover, weed and dead material were expressed as a percentage of the total number of counts.

Two 24-hour grazing behaviour studies were carried out during each faecal collection period (P122-P125, P135-P139) using an interval sampling technique, where it is assumed each record is representative of an activity over the time interval since the previous record (Hodgson 1982). A 10 minute recording interval was chosen to provide a reliable measure of grazing behaviour traits of a continuous nature (Gary *et al.* 1970; Hodgson 1982). Only one replicate per treatment was observed as labour resources were limited to one person per observation period and only 24 ewes could be observed in each 10 minute period.

In such an intermittent recording system it was necessary to set a minimum "dwell time" of 10 seconds per animal to determine the current activity pattern with some degree of certainty. To remove daily environmental variation, each 24 hour observation period was split into four 6-hour intervals on consecutive days. Daylight hours were defined as 0710-1730 hours. During the darkness hours (1740-0700), individual ewe identification was not possible with the infra-red nightscope (Varo Noctron V, Nightscope) used and therefore only treatment group grazing activity was recorded. Rates of biting during morning and afternoon grazing sessions were estimated during each observation period. The "20-bite" method was used, in which the time taken for each ewe to make 20 uninterrupted bites is recorded using a stopwatch (Hodgson 1982). The definition of a bite used was that there was head movement associated with the severance of a bunch of herbage (or an individual leaf) gripped in the mouth (Hodgson 1982). The mean biting rate (mean of three records/ewe) was used to compute a bite rate/minute (BR) for each ewe. Intake per bite (IB) was then calculated from total daily grazing time (GT) and the organic matter intake (OMI) indirectly estimated by the CRC chromium technique by rearranging the equation of Allden & Whittaker (1970):

$$IB = \frac{OMI}{GT \times BR}$$

Statistical Methods

Data relating to pasture measurements were subjected to univariate analysis of variance at each sampling time to test the effects of breeding policy (June v. August), SSH treatment and their interactions. Ewe intake, condition score, backfat thickness, midside wool growth and lamb liveweights were analysed using repeated measures analysis of variance (Gill & Hafs 1971). The SSH treatment x replicate mean square was used as the denominator to test for the effect of SSH while the error mean square was used to test for other main effects and their interactions. Ewe age was classified as 2-year-old or mixed aged ewes (ie ewes aged 3- to 5-year-old). Litter size was taken retrospectively as number of lambs born for pre-lambing traits and number of lambs weaned for post-lambing traits.

The model used was therefore:

$$Y_{ijklmn} = \mu + P_i + T_j + R_{j(k)} + A_l + L_m + PT_{ij} + PR_{ik} + PA_{il} + PL_{im} + TA_{jl} + TL_{jm} + RA_{kl} + RL_{km} + AL_{lm} + e_{ijklmn} \qquad \textit{(Model 6.1)}$$

where

Y_{ijklmn} = an observation on the *n*th ewe of the *i*th policy, the *j*th SSH treatment, the *k*th replicate, the *l*th ewe age and the *m*th litter size.

μ = the general mean.

P_i = the fixed effect of the *i*th breeding policy ($i=1$ or 2).

T_j = the fixed effect of the *j*th SSH treatment ($j=1...4$).

$R_{j(k)}$ = the effect of the *k*th replicate nested within the *j*th SSH treatment ($k=1$ or 2).

A_l = the fixed effect of the *l*th ewe age ($l=1$ or 2).

L_m = the fixed effect of the *m*th litter size ($m=1$ or 2).

PT_{ij} = the interaction of the *i*th policy with the *j*th SSH treatment.

PR_{ik} = the interaction of the *i*th policy with *k*th replicate.

PA_{il} = the interaction of the *i*th policy with the *l*th ewe age.

PL_{im} = the interaction of the *i*th policy with the *m*th litter size.

TA_{jl} = the interaction of the *j*th SSH treatment with the *l*th ewe age.

TL_{jm} = the interaction of the *j*th SSH treatment with the *m*th litter size.

RA_{kl} = the interaction of the *k*th replicate with the *l*th ewe age.

RL_{km} = the interaction of the *k*th replicate with the *m*th litter size.

AL_{lm} = the interaction of the *l*th ewe age with the *m*th litter size.

e_{ijklmn} = the random residual associated with an observation on the *n*th ewe of the *i*th policy, the *j*th SSH treatment, the *k*th replicate, the *l*th ewe age and the *m*th litter size.

All third order interactions were non-significant and were deleted from the model as were any non-significant second order interactions. For the analysis of lamb birth weights, lamb sex and the interactions of lamb sex with other main effects was added to Model 6.1 while lamb birth weight was fitted as a covariate in Model 6.1 for the analysis of lamb liveweights at L54 and L77.

Differences between group means were tested according to pre-planned comparisons using t-test (Snedecor & Cochran 1967). Data were expressed in terms of means (±SEM). All analyses used the Statistical Analysis System computer package (SAS 1985).

RESULTS

Pasture measurements

The mean sward heights measured on the nominal 2.0, 4.0, 6.0 and 8.0 cm SSH treatments were 2.8, 4.0, 7.1 and 8.5 cm for the June swards and 2.7, 4.0, 5.9 and 7.8 cm for the August swards (Table 6.1). The EPM readings followed a similar trend to the HFRO sward stick readings. A significant ($P<0.01$) policy x SSH treatment interaction for herbage mass was observed. This reflected the fact that herbage mass was different for each of the June swards but for the August swards there was no difference in herbage mass between the 2.0 and 4.0 cm swards, each of which had lower herbage mass than the 6.0 or 8.0 cm swards. At the equivalent SSH treatment, herbage mass was lower in the August swards than in the June swards (Table 6.1).

There were no significant ($P>0.05$) differences between seasons or SSH treatments in the botanical composition of cut herbage. However there was a trend for the proportion of grass in the dry matter to increase and for the proportion of dead material to decrease as sward height increased.

Table 6.1 Sward height, herbage mass, botanical composition and *In vitro* digestibility of pasture prepared to four nominal sward surface heights for June- and August-lambing ewes.

	June				August				Pooled SE
	2.0	4.0	6.0	8.0	2.0	4.0	6.0	8.0	
Sward Height (cm)									
HFRO Sward Stick	2.8^{a}	4.0^{b}	7.1^{d}	8.5^{f}	2.7^{a}	4.0^{b}	5.9^{c}	7.8^{e}	0.2
Range for Sward Stick	1.9-3.6	3.0-4.7	5.2-7.8	7.5-9.9	2.2-3.6	3.4-4.8	4.8-7.5	6.9-9.1	
EPM[1]	3.6^{a}	4.9^{c}	8.0^{e}	9.2^{f}	3.2^{a}	4.2^{b}	5.1^{d}	8.7^{f}	0.2
Herbage Mass (kg DM/ha)	740^{a}	1152^{b}	1795^{c}	2438^{d}	548^{a}	792^{a}	977^{b}	1885^{c}	87
Botanical Composition (%)									
Cut Herbage[2]									
Grass	0.59	0.53	0.64	0.69	0.61	0.67	0.72	0.76	0.05
Clover	0.03	0.02	0.02	0.02	0.05	0.01	0.02	0.05	0.01
Weed	0.04	0.02	0.03	0.01	0.03	0.03	0.03	0.03	0.01
Dead	0.34	0.43	0.31	0.28	0.31	0.29	0.23	0.16	0.05
Extrusa[3]									
Grass	0.80	0.81	0.84	0.87	0.77	0.87	0.83	0.82	0.02
Clover	0.08^{c}	0.09^{c}	0.04^{ab}	0.02^{a}	0.03^{ab}	0.01^{a}	0.04^{ab}	0.07^{bc}	0.01
Weed	0.10	0.08	0.09	0.08	0.11	0.07	0.09	0.09	0.02
Dead	0.02^{a}	0.02^{a}	0.03^{a}	0.03^{a}	0.09^{b}	0.05^{a}	0.04^{a}	0.02^{a}	0.01
***In Vitro* Digestibility**[2]									
OMD	0.81^{bc}	0.80^{b}	0.79^{a}	0.79^{a}	0.82^{c}	0.83^{d}	0.83^{d}	0.82^{c}	0.01
DOMD	0.64	0.67	0.68	0.68	0.68	0.70	0.70	0.70	0.01
Ash	0.28^{d}	0.19^{bc}	0.15^{a}	0.15^{a}	0.23^{c}	0.20^{bc}	0.21^{c}	0.17^{ab}	0.02

1 Ellinbank Plate Meter.
2 Expressed as a proportion of total dry matter.
3 Expressed as occurrence by point analysis (see Materials and Methods).
abcdef Means within rows having superscripts with letters in common are not significantly different ($P>0.05$).

Botanical separation of the extrusa samples revealed a higher clover content in extrusa collected from the 2.0 and 4.0 cm (compared with the 6.0 and 8.0 cm) June swards but not for the August swards (reflecting a significant policy x SSH treatment interaction, $P<0.01$, Table 6.1). There was a higher dead material content in the extrusa from the 2.0 cm August swards than from the 4.0, 6.0 and 8.0 cm August swards. There were no differences in dead material content in the June swards reflecting a significant ($P<0.05$) policy x SSH treatment interaction for dead material content of the dry matter.

Organic matter digestibility (OMD) of the herbage decreased as sward height increased in June swards while in August swards there was no such trend for OMD. Likewise the ash content decreased as sward height increased in the June sward but this trend was not so evident in the August swards (significant policy x SSH treatment interaction for OMD and ash content, $P<0.01$, Table 6.1). The digestible organic matter in the dry matter (DOMD) did not differ between SSH treatments in either the June or the August swards.

Ewe Liveweight and Condition

There was no significant difference in liveweights between June- and August-lambing ewes on day P115 (59.4 ± 1.0 kg v. 61.8 ± 1.1 kg, Table 6.2). The August-lambing ewes gained significantly ($P<0.05$) more liveweight than June-lambing ewes from P115 to P140 (7.7 ± 0.6 kg v. 4.4 ± 0.6 kg). However at weaning (L77) there were no differences in liveweight between the two lambing policies (reflecting a significant policy x times interaction, $P<0.01$).

Table 6.2 Effect of lambing policy, sward height treatment, litter size and ewe age on ewe liveweight during pregnancy and lactation (Mean±SEM).

	No.	Liveweight (kg)				
		P115	P128	P140	L54[1]	L77
Policy						
June	45	59.4±1.0	63.1±1.1[a]	63.8±1.1[a]	52.0±1.3	53.2±1.2
August	45	61.8±1.1	66.0±1.1[b]	69.5±1.3[b]	50.9±2.1	57.3±2.0
Sward Height (cm)						
2.0	22	62.8±1.4	63.9±1.5	66.8±1.7	50.8±2.3	54.8±2.2
4.0	22	60.5±1.3	64.6±1.4	64.5±1.8	52.9±1.8	56.9±1.7
6.0	22	59.8±1.3	64.5±1.4	66.2±1.7	49.8±2.2	54.1±2.1
8.0	24	59.4±1.3	65.2±1.3	67.2±1.6	52.5±1.8	55.3±1.7
Litter Size						
1	50(46)[2]	60.1±0.9	63.9±1.0	66.1±1.2	53.2±1.4	56.6±1.3
2	40(24)	61.1±1.0	65.2±1.1	67.2±1.3	49.6±1.8	53.9±1.7
Ewe Age						
2	45	56.7±1.0[a]	60.4±1.0[a]	61.5±1.3[a]	46.7±2.3[a]	50.9±2.1[a]
>2	45	64.5±1.0[b]	68.7±1.0[b]	71.8±1.2[b]	56.1±1.2[b]	59.6±1.1[b]
Overall Mean	90	61.1±1.1	65.0±1.2	66.8±1.6	53.8±1.0	57.2±1.3

1 L0 for June-lambing ewes = 3 June,
L0 for August-lambing ewes = 17 August.
2 Number of lambs born or (number of lambs reared).
ab Means within main effects having superscripts with letters in common are not significantly different (P>0.05).

Sward height treatment had no significant effect on ewe liveweight at any of the weighings. However ewes grazing the 8.0 cm swards gained 7.8 kg in liveweight (averaged across policies) from P115 to P140 while ewes grazing the 2.0 cm swards gained 4.0 kg in liveweight during this period (P<0.10). Litter size had no effect on ewe liveweight. The 2-year-old ewes were significantly (P<0.05) lighter than mixed aged ewes at every weighing. This partly included a wool effect due to different shearing dates. The liveweights of the two age classes on P115 were 57.3±1.0 (2-year-old) and 61.4 ± 1.7 (mixed aged) v. 56.0 ± 1.8 and 67.5 ± 1.0 kg for June- and August-lambing ewes respectively. On P128 the liveweights were 60.7 ± 1.8 and 65.5 ± 1.1 v. 60.1 ± 1.9 and 71.9 ± 1.1 kg for June- and August-lambing ewes reflecting a significant ($P < 0.05$) policy x age interaction.

The June-lambing ewes had higher body condition score than August-lambing ewes ($P < 0.001$, Table 6.3) during the late pregnancy period. Sward height treatment and ewe litter size did not influence ewe condition score. There was a significant ($P < 0.05$) difference in body condition score between 2-year-old and mixed aged ewes at P115 but not at any of the other measurement days (Table 6.3).

Ultrasonic backfat depth was higher in June- than in August-lambing ewes on P115 and P140 but at weaning (L77) there was no difference between these groups (Table 6.3). Sward height treatment had no effect on backfat thickness. Ewes bearing twin lambs had lower backfat measurements on P115 and P140 than single-bearing ewes ($P < 0.05$). Two-year-old ewes had higher backfat measurements at weaning (L77) than mixed aged ewes on the 6.0 and 8.0 cm swards but not on the 2.0 and 4.0 cm swards, reflecting a significant ($P < 0.05$) SSH treatment x age interaction (averaged across policies) at L77 for backfat thickness.

Table 6.3 Effect of lambing policy, sward height treatment, litter size and ewe age on ewe condition score and ultrasonic backfat depth measured on d 115 and d 140 of pregnancy and d 77 of lactation (Mean±SEM).

	No.	Condition Score[1]			Backfat Depth (mm)		
		P115	**P140**	**L77[2]**	**P115**	**P140**	**L77**
Policy							
June	45	3.0±0.1^{b}	3.0±0.1^{b}	2.4±0.1	6.8±0.4^{b}	6.8±0.3^{b}	3.1±0.3
August	45	2.6±0.1^{a}	2.5±0.1^{a}	2.1±0.1	5.2±0.4^{a}	5.3±0.4^{a}	2.5±0.4
Sward Height (cm)							
2.0	22	2.6±0.1	2.6±0.1	2.2±0.2	5.9±0.5	5.4±0.5	2.7±0.4
4.0	22	2.9±0.1	2.8±0.1	2.2±0.1	5.8±0.5	5.9±0.5	2.6±0.3
6.0	22	2.8±0.1	2.8±0.1	2.5±0.2	6.9±0.5	7.2±0.5	3.3±0.4
8.0	24	2.8±0.1	2.7±0.1	2.2±0.1	5.5±0.5	5.6±0.5	2.6±0.3
Litter Size							
1	50(46)[3]	2.9±0.1	2.8±0.1	2.4±0.1	6.7±0.4^{b}	6.8±0.4^{b}	3.1±0.2
2	40(24)	2.7±0.1	2.6±0.1	2.1±0.1	5.4±0.4^{a}	5.2±0.4^{a}	2.4±0.3
Ewe Age							
2	45	3.0±0.1^{b}	2.8±0.1	2.3±0.2	5.9±0.4	6.2±0.4	3.3±0.4^{b}
>2	45	2.6±0.1^{a}	2.7±0.1	2.2±0.1	6.2±0.4	5.8±0.4	2.3±0.2^{a}
Overall Mean	90	2.8±0.1	2.7±0.1	2.2±0.1	6.0±0.4	6.1±0.3	2.6±0.3

[1] Condition Score using 10 x 0.5 scale (Jefferies 1961).
[2] L0 for June-lambing ewes = 3 June,
L0 for August-lambing ewes = 17 August.
[3] Number of lambs born or (number of lambs reared).
[ab] Means within main effects having superscripts with letters in common are not significantly different (P>0.05).

Ewe Intake and Grazing Behaviour

Examination of the Cr content of daily faecal samples from two ewes in the August-lambing group during P122-P125 indicated that the linear phase of Cr release had ceased prior to measurement or the capsules had been regurgitated. These two ewes were deleted from this part of the analysis.

There were no differences in OMI between June- or August-lambing ewes during P122-P125, but June-lambing ewes had lower OMI than August-lambing ewes from P135-P139 (1.5±0.1 v. 1.7±0.1 kg OM/ewe/d, P<0.05, Table 6.4). Ewes grazing the 2.0 cm SSH treatment had significantly (P<0.05) lower OMI during the periods P122-P129 and P135-P139 than those grazing the other swards. The highest intakes were recorded by ewes grazing the 8.0 cm SSH treatment but only for the period P122-P125 was this statistically significant (P<0.05, Table 6.4). Mixed aged ewes had higher OMI than 2-year-old ewes but litter size had no effect on OMI and all second and third order interactions were non-significant at either intake measurement period. The effects of lambing policy and SSH on DOMI were similar to those of OMI (Table 6.4).

Table 6.4 Effect of lambing policy, sward height treatment, litter size and ewe age on ewe organic matter and digestible organic matter intake at two periods during pregnancy (Mean±SEM).

	No.	Organic Matter Intake (kg OM/ewe/d)		Digestible Organic Matter Intake (kg DOMI/ewe/d)	
		P122[1]-P125	P135-P139	P122-125	P135-P139
Policy					
June	45	1.7±0.1	1.5±0.1[a]	1.4±0.1	1.2±0.1[a]
August	43	1.7±0.1	1.7±0.1[b]	1.5±0.1	1.4±0.1[b]
Sward Height (cm)					
2.0	21	1.4±0.1[a]	1.4±0.1[a]	1.1±0.1[a]	1.2±0.1[a]
4.0	21	1.8±0.1[b]	1.6±0.1[b]	1.5±0.1[b]	1.3±0.1[ab]
6.0	22	1.8±0.1[b]	1.6±0.1[b]	1.5±0.1[b]	1.3±0.1[ab]
8.0	24	2.0±0.1[c]	1.7±0.1[b]	1.6±0.1[b]	1.4±0.1[b]
Litter Size					
1	49	1.8±0.1	1.6±0.1	1.5±0.1	1.3±0.1
2	39	1.7±0.1	1.6±0.1	1.4±0.1	1.3±0.1
Ewe Age					
2	43	1.6±0.1[a]	1.5±0.1[a]	1.3±0.1[a]	1.2±0.1[a]
>2	45	1.8±0.1[b]	1.7±0.1[b]	1.5±0.1[b]	1.4±0.1[b]
Overall Mean	88	1.7±0.1	1.6±0.1	1.4±0.1	1.3±0.1

[1] P122 for June-lambing ewes = 7 May,
P122 for August-lambing ewes = 24 July.

[abc] Means within columns and main effects having superscripts with letters in common are not significantly different (P>0.05).

Table 6.5 Effect of lambing policy, sward height treatment, litter size and ewe age on grazing time, biting rate and intake per bite during late pregnancy (Mean ± SEM).

	No.	Grazing Time (minutes)[1]	Biting Rate (bites/min)	Intake per Bite[2] (mg OM)
Policy				
June	24	575 ± 12[a]	81 ± 2	34 ± 2
August	23	633 ± 12[b]	82 ± 2	33 ± 2
Sward Height (cm)				
2.0	12	653 ± 20[b]	87 ± 4	23 ± 3[a]
4.0	11	634 ± 15[b]	79 ± 3	32 ± 3[b]
6.0	12	604 ± 17[b]	81 ± 3	36 ± 3[bc]
8.0	12	523 ± 15[a]	78 ± 3	43 ± 2[c]
Litter Size				
1	27	606 ± 11	82 ± 2	32 ± 2
2	20	602 ± 13	80 ± 3	32 ± 2
Ewe Age				
2	24	604 ± 12	81 ± 2	32 ± 2
>2	23	603 ± 11	82 ± 2	35 ± 2
Overall Mean	47	602 ± 7	83 ± 1	33 ± 1

[1] Per 24 hour period.
[2] Intake per Bite = OMI/(Grazing Time x Biting Rate).
[abc] Means within main effects having superscripts with letters in common are not significantly different (P > 0.05).

June-lambing ewes spent less time grazing than August-lambing ewes (P < 0.05, Table 6.5). Ewes on the 2.0, 4.0, and 6.0 cm SSH treatments spent a significantly (P < 0.01) longer period of time grazing than ewes on the 8.0 cm SSH treatment. Ewe litter size and ewe age had no effect on the time spent grazing.

The rate of biting measured by the 20-bite method was not influenced by ewe lambing policy, sward height treatment, litter size or ewe age.

Intake per bite (calculated from OMI, grazing duration and rate of biting) increased with increasing sward height (Table 6.5). Ewes grazing the 2.0 cm SSH treatment ate 23 ± 3 mg OM/bite while those ewes grazing 8.0 cm SSH treatment consumed 43 ± 2 mg OM/bite ($P < 0.001$). Lambing policy, ewe litter size and age had no effect on ewe intake per bite.

Wool Production

There was no effect of sward height treatment on midside wool growth rate although ewes grazing the 8.0 cm sward tended to have higher midside wool growth rates than ewes grazing the 2.0, 4.0 or 6.0 cm SSH treatments (Table 6.6). During late pregnancy (P115-P140) lambing policy did not affect midside wool growth rate but from P140-L77 the August-lambing ewes grew more wool than June-lambing ewes (1187 ± 82 v. 911 ± 70 $\mu g/cm^2/d$, $P < 0.05$, Table 6.6). Litter size and ewe age had no effect on midside wool growth.

Ewes that reared single lambs had wool with a significantly ($P < 0.05$) higher MFD at weaning (L77) than ewes that reared twin lambs. Lambing policy, SSH treatment and ewe age and their interactions had no effect on MFD when measured at weaning (L77).

Table 6.6 Effect of lambing policy, sward height treatment, litter size and ewe age on midside wool growth from d 115 of pregnancy to d 77 of lactation and on mean fibre diameter measured on d 77 of lactation (Mean ± SEM).

	No.	Wool Growth ($\mu g/cm^2/d$)		MFD[1](μm)
		P115-P140	P140-L77	
Policy				
June	45	667±63	911±70[a]	39.8±0.6
August	45	600±62	1187±82[b]	39.9±0.9
Sward Height (cm)				
2.0	22	590±49	1017±74	40.3±1.1
4.0	22	624±46	1056±57	39.9±0.8
6.0	22	597±47	993±69	39.3±1.0
8.0	24	724±44	1130±57	39.9±0.8
Litter Size				
1	50(46)[2]	625±33	1038±43	41.0±0.6[b]
2	40(24)	642±37	1061±57	38.7±0.8[a]
Ewe Age				
2	45	609±39	1094±73	40.6±1.0
>2	45	658±36	1004±39	39.1±0.5
Overall Mean	90	635±30	1018±38	39.7±0.7

[1] Mean Fibre Diameter.
[2] Number of lambs born or (number of lambs reared).
[ab] Means within main effects having superscripts with letters in common are not significantly different (P > 0.05).

Lamb Production

Lambs born to June-lambing ewes had significantly ($P<0.001$) lower birth weights than lambs born to August-lambing ewes (4.4 ± 0.2 kg v. 5.3 ± 0.2 kg, Table 6.7). Single-born and male lambs were heavier at birth than twin-born and female lambs respectively. Sward height treatment and ewe age had no effect on lamb birth weight (Table 6.7).

High lamb liveweight gains in June-born lambs from birth (L0) to L54 resulted in these lambs having significantly ($P<0.01$) higher liveweights than August-born lambs at L54 (Table 6.7). However, at L77 there was no difference in liveweight between June- or August-born lambs, reflecting the faster liveweight gains in August-born lambs from L54 to L77.

Sward height treatment had no effect on lamb growth rates. Lambs reared as singles were significantly ($P<0.001$) heavier at L54 and L77 than twin-reared lambs (Table 6.7).

There was no difference in the liveweight of lambs reared by 2-year-old or mixed aged June-lambing ewes. However, lambs born and reared by August-lambing 2-year-old ewes were lighter at L54 (10.6 ± 1.0 kg) and L77 (17.4 ± 1.2 kg), than lambs born and reared by mixed aged August-lambing ewes at L54 (12.8 ± 0.5 kg) and at L77 (21.1 ± 0.5 kg), reflecting a significant ($P<0.01$) policy x age interaction.

June-born male lambs were heavier than their female counterparts at weaning (L77), but there was no effect of sex lamb on liveweight at weaning (L77) in August-born lambs, reflecting a significant ($P<0.05$) policy x sex interaction for lamb weaning weight.

Table 6.7 Effect of lambing policy, sward height treatment, litter size, lamb sex and dam age on lamb birth weight and liveweight at d 54 and d 77 of lactation (Mean ± SEM).

	No.	Liveweight (kg)		
		Birth	L54[1]	L77
Policy				
June	69(48)[2]	4.4±0.2[a]	16.3±0.4[b]	19.7±0.5
August	61(46)	5.3±0.2[b]	11.7±0.6[a]	19.3±0.7
Sward Height (cm)				
2.0	30(24)	4.9±0.2	12.7±0.7	18.6±0.8
4.0	32(21)	5.1±0.2	15.2±0.5	20.4±0.6
6.0	36(24)	4.8±0.3	13.6±0.7	19.2±0.8
8.0	32(25)	4.8±0.2	14.3±0.5	19.7±0.6
Litter Size				
1	50(46)	5.5±0.2[b]	14.8±0.4[b]	20.7±0.5[b]
2	80(48)	4.2±0.1[a]	13.1±0.5[a]	18.2±0.6[a]
Lamb Sex				
Female	67(48)	4.7±0.1[a]	13.9±0.4	19.1±0.5
Male	63(46)	5.1±0.2[b]	14.1±0.4	19.8±0.2
Dam Age				
2	62(38)	4.8±0.2	13.6±0.6	18.6±0.7
>2	68(56)	5.0±0.2	14.4±0.3	20.3±0.4
Overall Mean	130(94)	4.8±0.2	14.4±0.2	20.1±0.2

[1] L0 = 3 June for June-born lambs,
L0 = 17 August for August-born lambs.
[2] Number of lambs born or (number of lambs reared).
[ab] Means within main effects have superscripts with letters in common are not significantly different (P>0.05).

DISCUSSION

The objective of this experiment was to compare the effect on ewe and lamb performance of a range of sward surface heights during the last 4 weeks of pregnancy in June- and August-lambing ewes.

Maintaining swards at differing SSH in an experiment that extends over periods of 4 weeks within each of two distinctly different seasons presents a difficult practical problem. Within season, it is desirable to maintain SSH and other sward conditions constant so that differences measured in animal intake and performance can be related to those SSH and sward conditions. In the experiment reported here, pasture mass, SSH and measures of herbage quality remained relatively constant within each lambing policy over the 4 week experimental period. This was achieved by choosing stocking rates that allowed animal requirements to closely match herbage growth rate and by the addition or removal of non-trial buffer stock (in this case rising 1-year-old heifers).

There was also a need to maintain the same SSH between seasons as the objective of the experiment was to compare animal performance v. SSH relationships between the two seasons. Differences in SSH between seasons would make interpretation of animal intake and performance data difficult. Actual sward surface heights on each of the nominal SSH treatments were successfully maintained at similar levels between seasons, although SSH on the nominal 6.0 and 8.0 cm swards were higher in autumn than in spring. However at the same nominal SSH, herbage mass was lower in the August swards compared with the June swards, primarily because of a higher dead material content and an associated lower green herbage content in the June swards. The lower green herbage content also contributed to a lower organic matter digestibility content in the June swards. Therefore although SSH was controlled between seasons, herbage mass at a particular SSH was confounded with season. This does, however, represent the normal situation when different lambing policies are compared between seasons. The differences in herbage mass and sward conditions measured between seasons must therefore be considered when attempting to explain differences in animal intake or performance occurring between the seasons when animals graze at a similar SSH.

Animal Intakes and Ingestive Behaviour

The relationship between ewe intake and SSH was similar between seasons. However the relationship varied with stage of pregnancy, OMI increasing up to a SSH of 8.0 cm during the period P122-P125 and to a SSH of 4.0 cm during the period P135-P139. The increased intakes for the higher SSH resulted in greater ewe liveweight gains but no change in condition score or backfat thickness. Bite weight increased, while grazing duration decreased as SSH increased. Relative to ewes on the 8.0 cm swards, those on the 2.0, 4.0 and 6.0 cm SSH treatments attempted to increase their intakes by increasing their grazing duration. This compensation was not complete for ewes on the 2.0 cm SSH treatment, hence their lower intake per bite and lower total daily OMI. The ewes on the 2.0 cm SSH treatment had probably reached their maximum grazing time as the 653 minutes (10.9 hours) of grazing recorded for these ewes is at the upper end of comparable research results reported for of sheep (Hodgson 1982; Forbes & Hodgson 1985; Hart 1985; Penning 1986).

Biting rate was not influenced by SSH. This is contrary to the results of Penning (1986) who found that with ewes grazing a SSH of 3.0, 6.0, 9.0 or 12.0 cm, biting rate increased as SSH decreased. However, the trend in the results reported in this chapter is similar to that of Penning (1986), ie 87 and 78 bites/minute for 2.0 and 8.0 cm SSH treatments, respectively.

The maximum OMI of 2.0 kg OM/ewe/d (ca. 2.4 kg DM/ewe/d) recorded on the 8.0 cm SSH treatment during the period P122-P125 represents a dry matter intake of 3.7% of ewe liveweight. In comparison the intake of 1.7 kg OM/ewe/d (ca. 2.0 kg DM/ewe/d) recorded on the 8.0 cm SSH treatment from P135-P139 represents 2.9% of ewe liveweight. These results are comparable with the DMI intake of 2.5 kg/ewe/d (3.6% of liveweight) reported by Rattray & Jagusch 1978 for ewes grazing on unrestricted herbage allowance.

Likewise the OMI measured over late-pregnancy of 1.4 kg OM/ewe/d (ca. 1.7 kg DM/ewe/d) for ewes on the 2.0 cm swards compare favourably with dry matter intakes of 1.7 kg DM/ewe/d for ewes fed restricted herbage allowances reported by Rattray *et al.* (1982a). The OMI measured on the 4.0, 6.0 and 8.0 cm swards, which ranged from 1.6-2.0 kg OM/ewe/d (1.9-2.4 kg DM/ewe/d), are similar to the 1.8-2.1 kg OM/ewe/d reported Parker *et al.* (1991) and the 1.8 kg DM/ewe/d found by Geenty & Sykes (1986) for single- and twin-rearing ewes of a similar liveweight and grazed at comparable pasture allowances. The ewe OMI measured in this trial are also similar to those of Gibb & Treacher (1982) who fed ewes a pelleted ration to either maintain ewe body weight or produce a loss of ewe body weight of 150 g/d. Ewes fed to lose 150 g/d of body weight had an OMI of 1.44 kg OM/ewe/d while those fed to maintain body weight had an OMI of 1.97 kg OM/ewe/d. Hadjipieris & Holmes (1966) however, measured much lower DMI (1.2-1.3 kg DM/ewe/d) in pregnant ewes fed indoors than in the trial reported here. They fed ewes a hay-based diet and this bulky diet may have physically limited intake in their ewes.

The calculated energy intakes at P135-P139 for the twin-rearing ewes in this trial (20.8 MJ ME/ewe/d) are slightly lower than the 23.2 MJ ME/ewe/d recommended by Rattray (1986). The single-rearing ewes, however, had energy intakes (21.6 MJ ME/ewe/d) considerably higher than the 18.5 MJ ME/ewe/d suggested by Rattray (1986) for 65 kg single-bearing ewes one week prior to lambing. Single-bearing ewes were able to achieve their recommended energy intake at SSH of 2.0 cm over the last month of pregnancy while twin-bearing ewes achieved their required energy intakes at SSH of 4.0 cm. Ewes responded to increased energy intakes at higher SSH by increasing liveweight gains.

In summary, ewe intakes increased as SSH increased up to the maximum SSH of 8.0 cm 3-4 weeks before parturition and to a maximum SSH of 4.0 cm 1-2 weeks prior to parturition. These relationships were similar for June- and August-lambing ewes.

Wool and Lamb Production

Sward surface height had no effect on ewe midside wool growth or MFD. This finding was consistent across seasons. Rattray & Trigg (1979) also noted a small and non-significant effect of herbage allowance on wool growth when they fed ewes a pelleted ration indoors within the range of 1.0 x Maintenance (M) to 2 x M for the last 6 weeks of pregnancy. Others have noted that wool growth is clearly responsive to herbage allowance over the winter months (Rattray & Jagusch 1978; Allden 1979; Horton & Wickham 1979; Hawker *et al.* 1982; Rattray *et al.* 1982a; Oddy 1985). The response to increasing pasture allowance was, however, much less during the winter than during either the autumn or spring (Hawker *et al.* 1982).

No measurements of MFD were taken on P140 as the midside samples taken had clean weights of less than 1.0 g, a weight considered too light for the airflow technique of measuring MFD (Sumner 1969). Although the measurement of MFD on L77 (measured on midside wool sample grown from P140-L77) is outside the SSH treatment period (P115-P140) it may represent a proportion of wool grown during the SSH treatment regimen. This is because there is a "emergence time" lag of between 5 and 20 days before a change in wool growth can be measured above the skin (Rattray *et al.* 1987). Therefore the MFD taken on L77 might represent a portion of the wool grown during the SSH treatment period (ie P120-L57).

Lamb birth weights and subsequent lamb liveweights were not affected by SSH. This result was consistent across seasons and probably reflects the buffering capacity of 60-65 kg ewes grazing the 2.0 cm SSH treatment whereby they were able to mobilize body tissue to produce lambs of a satisfactory birth weight. However, this mobilization of body tissue was not reflected in corresponding SSH treatment effects on body condition score or backfat depth (both of which are measures only of peripheral tissue deposition or mobilization). Conversely ewes of this liveweight grazing high pasture allowances (4-8 cm) tended to divert their extra intake to liveweight gain rather than to foetal growth. These findings concur with those of Rattray *et al.* (1982a) who found that pre-partum herbage allowance had no consistent effect on the birth weight of lambs. Other researchers have noted positive effects of late pregnancy feeding on lamb birth weights (Wallace 1948; Russel *et al.* 1967a, 1967b; Khalaf *et al.* 1979; Rattray & Trigg 1979; Holst & Allan 1992; Holst *et al.* 1992;). These differences in research results are likely to be a function of differences between experiments in the condition score of ewes. Ewes with greater maternal reserves can mobilize body tissue to support foetal growth during periods of underfeeding while light and poorly conditioned ewes would not have this opportunity.

Of particular note were the large differences, measured across all SSH treatments, in lamb birth weights between seasons. Some of this difference in birth weight can be accounted for by the difference in intakes between June- and August-lambing ewes measured during the second intake period (P135-P139). This difference in intake, however, only contributes 2.9 MJME/ewe/d and, considering that the efficiency of conversion of ME in the diet to energy gain in the foetus is only 13% (MLC 1981), effects other than nutrition are likely to contribute to these differences in birth weight. There was a difference ($P<0.05$) in gestation length (or, more correctly, the interval between time of CIDR removal and birth of lambs) for June- and August-born lambs (149.2 ± 0.4 v. 150.6 ± 0.4 days). Single and twin foetuses grow on average 200 g/d at day 140 of gestation (Rattray *et al.* 1974). Therefore the extra 1.4 days of gestation for the August-born lambs could account for approximately 0.3 kg of the 0.9 kg extra birth weight in August-born lambs compared to June-born lambs.

The seasonal effect on birth weight agrees with the results of Reid *et al.* (1988) who found in two separate years that autumn-born lambs were 0.4 kg lighter than spring-born lambs. Cruickshank & Smith (1989) also found a strong seasonal effect on lamb birth weight. Likewise, Obst *et al.* (1991) found that Australian Merino lambs born in May were significantly ($P<0.05$) lighter than August-born Merino lambs (3.8 v. 4.0 kg).

In conclusion, this trial has shown that, at the same SSH, June-lambing ewes can achieve similar intakes to August-lambing ewes. However, the June-born lambs are lighter at birth than their August-born counterparts. Ewes that are in a good body condition can achieve their required intakes on a SSH maintained at 2.0 cm. Therefore it can be recommended that a SSH of 2.0 cm is a suitable target over last month of pregnancy for continuously stocked ewes in a good condition (condition score 2.5-3.0). For June-lambing ewes this recommended target SSH might extend to ewes in poorer condition, since they can be weaned in early spring onto high quality pasture (11.0 MJ ME/kg DM) and therefore have greater opportunity to recover liveweight before mating. In the normal (spring-lambing) situation weight loss over the last month of gestation in ewes in a poor condition would be unacceptable. Therefore, although the SSH/intake and performance relationships are similar between seasons, actual SSH targets for grazing management might differ in recognition of the different seasonal liveweight gain profiles possible for June- and August-lambing ewes. This issue will be addressed further in Chapter VII.

CHAPTER VII

GENERAL DISCUSSION

The main objective of this research programme was to investigate issues relating to the development of systems for out-of-season lamb production in the lower North Island of New Zealand. Out-of-season lamb production offers sheep farmers the opportunity to extend the lamb slaughtering season beyond the normal high seasonal peak from December to May. An extended slaughter pattern will allow lambs to be produced on a year-round basis and will therefore help the New Zealand sheep industry to compete as a supplier of the lucrative Northern Hemisphere chilled lamb trade. Furthermore, if the predicted scenarios for climate change become a reality, then autumn/winter-lambing ewe flocks are likely to have feed demand profiles that match the projected shifts in seasonal pasture production. Sheep farmers wishing to diversify or to increase the flexibility of their farm system might also use out-of-season lamb production on only a proportion of their ewe flock to spread labour requirements and to take advantage of early season premiums for lambs and cull ewes. For these reasons it is timely to consider the development of systems for out-of-season lambing even though current lamb meat returns do not make these systems viable for lower North Island farms at the present time.

In most experimental situations, factors which could influence the measured parameters are controlled by randomisation of animals to treatment groups and/or by the experimental protocol leaving only the one factor of interest "variable". However, any experimental programme which attempts to compare performance of animals across different seasons is inevitably faced with the fundamental problem that experimental conditions cannot be precisely controlled between seasons. This problem existed throughout the present study (the sole exception being Chapter V) since not all the variables which contributed to the "season/policy" effect (eg herbage allowance and quality, ambient temperature, photoperiod) could be precisely controlled. Allocation of the same pasture mass (or the same pattern of changes in pasture mass) to ewes in the two policies went some way to controlling this problem but did not do so completely. This is because, under grazing conditions, the two groups (policies) of ewes could never be exposed to exactly the same patterns of pasture mass (especially during the experiments reported in Chapters II-IV which were run under commercial conditions) and because it was not possible to control the other variables which contribute to between-season variation. As a consequence, it was possible to characterise the magnitude of season/policy effects but not to control or describe the components of these effects.

One major constraint to out-of-season breeding is the highly seasonal breeding pattern of New Zealand sheep breeds. Most of the breeds used most widely in the North Island commence cyclic activity in February/March and continue until June/July. Although hormonal techniques are readily available to ensure that ewes mate outside their normal lambing season, breeds or crosses that will mate naturally over extended periods would be better suited to future out-of-season breeding programmes. These breeds should also be chosen to excel in annual fleece production, and in number and weight of lambs weaned per ewe mated.

Three ewe crosses were evaluated in this research programme. They were: the Border Leicester x Romney (BR), a popular dam of prime lambs in the lower North Island; the Poll Dorset x BR (PBR), a cross chosen to represent a breed (the Poll Dorset) which has a long breeding season and good mothering ability; and the Suffolk x BR (SBR), an unconventional cross not used in New Zealand but chosen primarily because the Suffolk and its crosses are used as dams of heavyweight prime lambs in the UK and USA. Canadian research has suggested that the Suffolk might also have an extended breeding season but there is no information on how Suffolk cross ewes perform under New Zealand conditions. These three crosses were initially evaluated at the ewe hogget stage for wool production, growth and occurrence of hogget oestrus under commercial farming conditions. The same crosses were then assigned to either a June- or August-lambing policy and evaluated in terms of lamb and wool production.

The research confirmed previous findings, namely that June-lambing ewes wean fewer lambs than August-lambing ewes, primarily because of a lower proportion of multiple births. August-born lambs were heavier at birth and at weaning than their June-born counterparts but there were no differences in lamb losses between the two policies. Therefore farmers contemplating shifting part or all of their flock to a June-lambing system can expect a decrease in reproductive rate and in weight of lamb weaned per ewe mated. These decreases in production would need to be offset by higher prices for the June-born lambs or by greater wool production/income from June-lambing ewes if this out-of-season lambing policy were to be profitable.

Of particular note was the higher wool production of June-lambing ewes compared to their August-lambing counterparts. This result agrees with those of Reid *et al*. (1988) and Reid and Sumner (1991). The extra wool produced by the June-lambing ewes ranged between 0.1 and 1.0 kg over the 5 years of the trial and was consistent across all ewe crosses and the two age groups. The income from this extra wool will help offset any increased costs associated with out-of-season breeding (eg CIDRs) and partly compensates for the lowered lamb production compared to August-lambing ewes.

There were no major differences in reproductive performance between any of the three ewe crosses used, although PBR ewes tended to wean the heaviest lambs. Border Leicester x Romney ewes produced the most wool and PBR ewes were slightly better for wool production than the SBR ewes. A simple economic analysis indicated that BR ewes provided the best returns per ewe under a June-lambing policy and, in the absence of any large ewe cross differences in returns per ewe in the August-lambing policy, BR ewes would be the preferred choice of ewe cross for sheep farms having a mix of June- and August-lambing ewes.

When ewe hogget performance is included, the BR remains the preferred choice. This is primarily due to the extra wool produced by the BR hoggets compared to PBR and SBR hoggets. The extra returns from wool more than compensate for the lighter liveweight of, and hence lower price achieved for, BR hoggets surplus to requirements compared to the heavier SBR and PBR ewe hoggets.

The superiority of BR cross was, however, determined within the constraints of a system which relied on the use of CIDRs for out-of-season mating. Farmers wishing to produce out-of-season lambs for the least possible cost might favour a breed or cross of ewe, such as the Poll Dorset x BR, that is expected to have a naturally extended breeding season. However, it is important to note that the onset/length of the breeding season was not assessed for each cross in this study, so that no firm recommendations can be made regarding the most desirable cross under a natural mating (non-CIDR) out-of-season lambing policy. If sufficient ewes and funding had been available, a third policy group of ewes could have been included in the experiment. This group would have been mated without CIDRs to achieve June-born lambs and would therefore have provided information on how the three ewe crosses performed under a non-CIDR system of mating. The ranking of ewe crosses might have changed under these circumstances and favoured the PBR ewes because of their presumed inherently longer breeding season.

The financial returns calculated in this study for the different ewe crosses reflect the 1990/1991 wool and lamb prices. Historically the ratio of lamb to wool has fluctuated between 4:1 and 8:1 and as this ratio changes so too will the ranking of the various ewe crosses change. For example, as lamb price increased relative to the wool price, the returns per ewe for PBR and SBR ewes would increase compared to those for the BR ewes. In general, though, the results of this study suggest that BR ewes are likely to be favoured over PBR or SBR ewes in the situation where only a proportion of the flock is being mated to lamb out of season.

One of the major findings from the field trial reported in Chapter III was that June-lambing ewes had a greater annual greasy fleece weight than August-lambing ewes, a result consistent with previous literature reports. The next step in the study programme was to determine the monthly pattern of wool growth in ewes lambing under the two policies (Chapter IV). This study aimed to identify the times of the year when differences in wool production occurred and to examine how the changes in wool growth affected wool quality. A group of rising 4-year-old ewes originating from the earlier study (Chapter III) were used for this purpose.

The results of the above experiment indicated that the pattern of wool growth was markedly different between June- and August-lambing ewes. Both groups exhibited seasonality of wool production, but the June-lambing ewes had a much lower winter wool depression in both absolute and proportional terms. This flatter wool growth curve in June-lambing ewes was associated with an increase in mean fibre diameter and a higher wool tensile strength when measured at the following October shearing. Wool from June-lambing ewes was also brighter and whiter than wool from August-lambing ewes.

There was one contradiction in the results, namely that the higher fleece weights in June-lambing ewes compared with August-lambing ewes (at both the 1988 and 1989 October shearings) were not paralleled by a greater total wool growth on the midside of June-lambing ewes throughout the 392 days of the trial. The explanation for this is that there were two periods outside the midside sampling regimen included in the annual fleece weights taken in October 1988 and 1989 and that these periods accounted for the differences in fleece weight measured between the two policies. In hindsight the 12-monthly midside sampling interval should have coincided with the interval between the two annual shearing dates so that total midside wool growth rate over the 12-month sampling interval could be related directly to annual fleece production measured at shearing. However, that was not practical within the constraints of this study programme.

Differences in wool quality measured between the ewe crosses tended to average out once all the wool quality traits were considered. For example, the wool from BR ewes had a higher tensile strength than wool from SBR ewes but the SBR wool had a higher bulk value than the BR wool. When all the wool quality traits are considered in the analysis of returns per ewe, the BR remains the preferred choice for both lambing policies.

The absence of an appreciable winter break in the wool of June-lambing ewes suggests that a pre-lamb shear in late autumn followed by a late spring shear prior to mating would be the logical sequence for a twice-yearly wool harvesting policy in autumn/winter-lambing ewes. The wool shorn in late spring would have good colour and high tensile strength, while the autumn-shorn wool would be similar to the high quality second shear wool that is usually shorn during this period in the North Island (Stanley-Boden *et al.* 1986). Alternatively, a once-yearly shearing regimen in October or November would suffice for June-lambing ewes, primarily because of the absence of a winter break in the fibre. Annual pre-lamb shearing of June-lambing ewes would have the major disadvantage of ewes carrying a relatively heavy fleece through the summer period and hence being at risk of high ecto-parasite burdens and flystrike infection.

Widespread adoption of autumn/winter-lambing policies will require that pasture allowance/intake/production relationships be more clearly defined for pregnant and lactating ewes under these policies. Until now it has generally been assumed that the relationships derived for spring-lambing ewes also hold for autumn/winter-lambing ewes. However, this assumption may not be valid because of the altered pattern of feed demand relative to pasture production in winter-lambing ewes. Furthermore, most of the existing relationships are derived from rotational stocking experiments rather than continuous stocking which is likely to be the grazing system adopted on most farms, particularly during lactation.

Two studies were therefore undertaken to examine the relationship between sward surface height, ewe intake and productivity in lactating winter-lambing ewes (Chapter V), and pregnant winter- and spring-lambing ewes (Chapter VI). These two studies were designed to generate data which would provide recommendations of appropriate sward surface heights for continuously stocked June-lambing ewes and, in the case of Chapter VI, a revision of recommendations for pregnant August-lambing ewes.

The relationships derived in this study between sward surface height over the last month of pregnancy and ewe ME intake, liveweight change, midside wool growth and lamb birth weight are shown in Fig. 7.1 for June- and August-lambing ewes. Ewe ME intake and liveweight gain increased as SSH increased, relationships which were generally consistent between June- and August-lambing ewes. Ewe midside wool growth was not influenced by SSH or lambing policy, although the trend was for wool growth to increase as SSH increased and for June-lambing ewes to grow more wool than August-lambing ewes over the final month of pregnancy. Likewise, lamb birth weights were not markedly influenced by SSH. Of particular note was the large difference in lamb birth weights between June- and August-lambing ewes. The June-born lambs were consistently 10-35% lighter than their August-born counterparts across all of the SSH treatments. While some of the increase in lamb birth weight can be explained by the increased liveweight gain of August-lambing ewes and their slightly longer gestation period, other seasonal factors are also likely to be responsible for the difference. Further investigations are needed to explain this difference. These would require the use of controlled feeding levels, serial slaughter of ewes during gestation and measurement of foetal growth within each of two lambing policies. Differences in lamb birth weight are important because they could have a major influence on lamb mortality, especially under cold, wet and windy conditions at lambing. As shown in this study, they are also associated with differences between the policies in weaning weight which is an important measure of flock productivity.

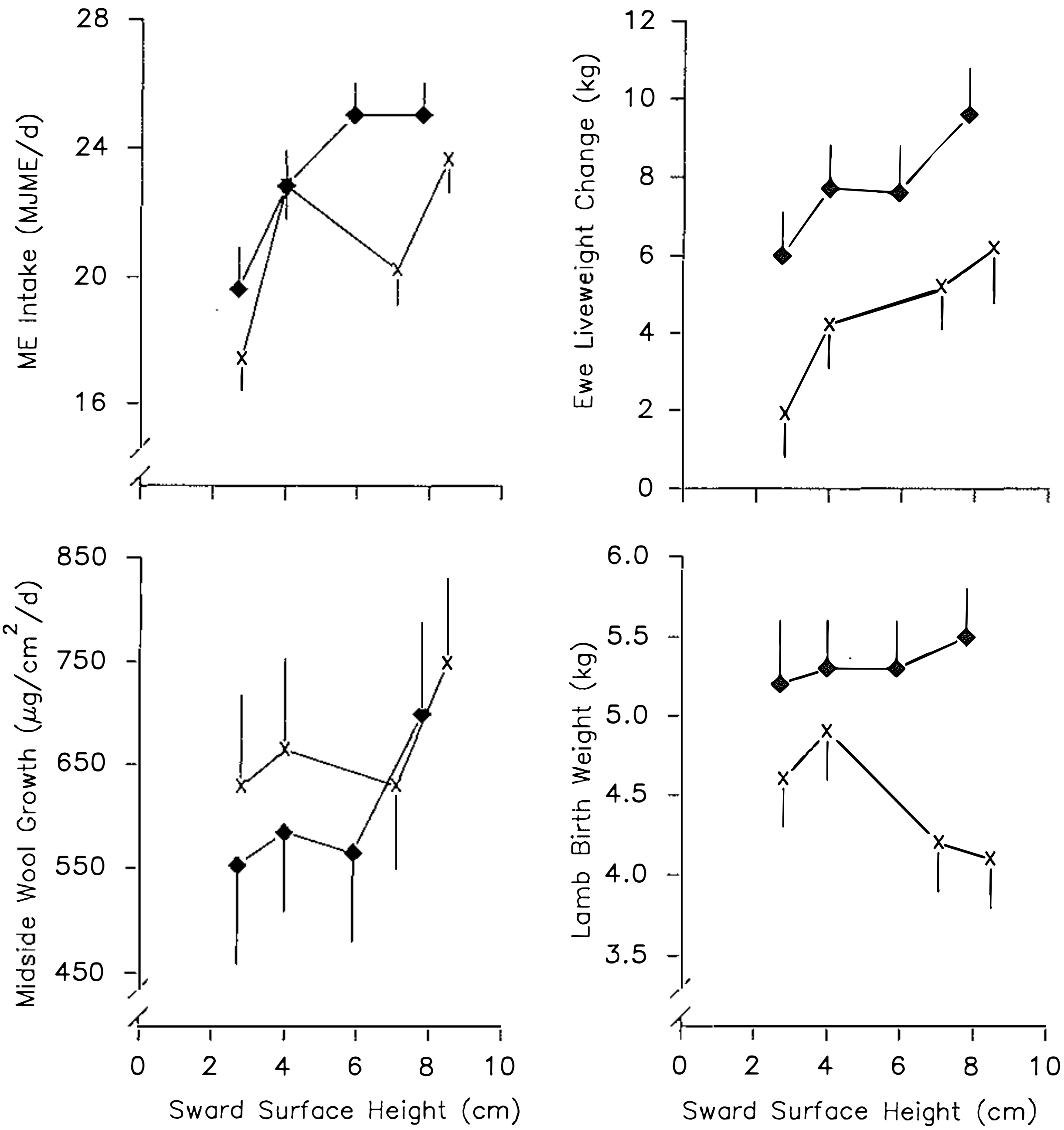


Fig. 7.1 The effect of sward surface height on ewe metabolisable energy (ME) intake, liveweight change, midside wool growth rate and lamb birth weight in pregnant June- (x) and August-(♦)lambing ewes. ME intakes are the means±SEM of two intake periods P122-P125 and P135-P139 where P122 refers to pregnancy d122 (for June-lambing ewes P122 = 7 May while for August-lambing ewes P122 = 24 July).

The effects of SSH during lactation on ewe intake, liveweight change, midside wool growth and lamb liveweight taken on lactation day 60 are shown in Fig. 7.2. The data of Parker (1990) are included to give a comparison between June- and August-lambing ewes. Although not strictly comparable with the June-lambing ewes reported in this study, the experimental results relating to August-lambing ewes (Parker 1990) were collected one year earlier on the same paddocks and over a similar range of sward surface heights.

As sward surface height increased, ewe ME intake increased but at a diminishing rate. Once a SSH of 6.0 cm is reached, ewes are probably physically unable to harvest the extra available dry matter to further increase intake. Lamb liveweights taken on day 60 of lactation increased marginally as SSH increased, but most of the extra energy available to ewes was diverted to liveweight gain or, in the case of June-lambing ewes, to the prevention of liveweight loss. There was no effect of SSH on ewe midside wool growth in either policy.

The results of this study therefore indicate that ewes continuously stocked on swards of 2.0 cm can achieve lamb birth weights and wool growth rates over the last month of pregnancy comparable to those of ewes stocked on higher SSH pastures. These same ewes can be stocked on to relatively short swards (2.6 cm) during lactation without penalising lamb or wool production. However, at these very low SSH, ewes will lose up to 10 kg in liveweight. This loss in liveweight may not be detrimental to long term production in June-lambing ewes as these ewes generally have the opportunity to regain this liveweight after weaning during the spring period of maximum herbage growth and quality. This scenario does not apply to August-lambing ewes which need to regain the lost liveweight over the summer months when herbage growth and quality are lower than in the spring.

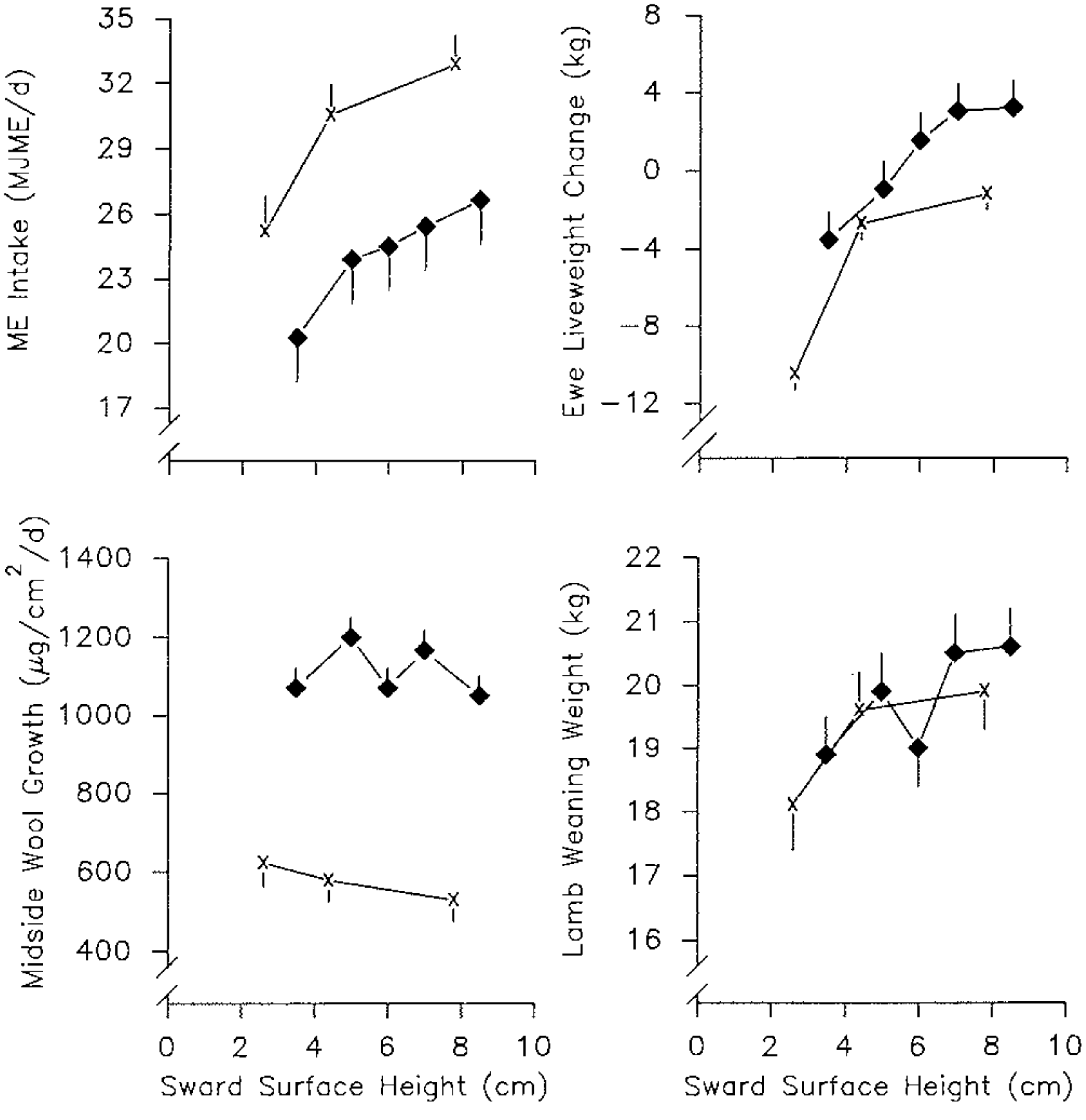


Fig. 7.2 The effect sward surface height on ewe metabolisable energy (ME) intake, liveweight change, midside wool growth rate and lamb weaning weight in lactating June-(x) or August(♦)-lambing ewes (August data from Parker 1990). ME intakes for June-lambing ewes are the means±SEM of four intake periods L13-L18, L25-L28, L41-L44 and L50-L55 where L13 refers to lactation day 13 (23 June). For August-lambing ewes ME intakes are the mean ± SEM of two intake periods L27-L32 and L59-L62 where L27 = 16 September.

As a result, different SSH recommendations are appropriate for June- and August-lambing ewes during lactation. A SSH of 4-6 cm is recommended for August-lambing ewes (Parker 1990) while data derived from this study suggest that June-lambing ewes can achieve acceptable lamb growth rates at SSH as low as 2.6 cm, provided that generous feeding of ewes is possible in late spring.

The following conclusions can be drawn from this study with respect to the development of out-of-season lamb production systems for the lower North Island and to areas in which further research is warranted.

1. Border Leicester x Romney ewes are likely to be preferred over PBR and SBR ewes in a June-lambing policy where out-of-season mating is accomplished using CIDRs and high ram to ewe ratios. This is especially the case when a farmer uses a mix of out-of-season and normal lamb production systems. However, in situations where the whole flock is to be mated out-of-season, a cross such as the Poll Dorset x BR may be a better choice because of the Poll Dorset's extended breeding season. If this option was to be considered then the ewe crosses would need to be further evaluated in an out-of-season mating system that did not use CIDRs. The experiment on hogget performance (Chapter II) would not need to be repeated since the effects of ewe cross on hogget performance are independent of methods by which subsequent out-of-season breeding is induced.

2. Ewes lambing out-of-season produce more wool than ewes lambing in the spring. This extra wool production can partly offset the extra cost of the CIDRs used to induce out-of-season breeding and/or compensate for the lowered lamb production from out-of-season lambing ewes. Associated with this extra wool production is an improvement in wool quality, particularly fibre diameter and tensile strength, resulting in a lower incidence of seasonal break in the fibre compared to wool from spring-lambing ewes.

3. Shearing policies that fit the altered wool growth pattern of out-of-season lambing ewes appear to include annual, twice-yearly or 8-month shearing policies. A pre-lamb shear followed by a pre-mating November shear would allow best advantage to be taken of the high winter wool growth in out-of-season lambing ewes. Where a farm has a mix of out-of-season and normal lamb production, this second shearing regimen would not disrupt a second shear policy of normal lambing ewes as the pre-lamb shear for out-of-season lambing ewes would coincide with a post-mating second shear of normal-lambing ewes. Alternatively a once-a-year shearing policy in November would be suitable for out-of-season lambing ewes as the wool grown during the winter contains a low incidence of fibre breaks and the November shearing coincides with normal shearing times. However, no research directly comparing different shearing policies in out-of-season lambing ewes has yet been undertaken in New Zealand.

4. Ewes lambing out-of-season have fewer multiple births than spring-lambing ewes. Furthermore, birth weights and weaning weights of winter-born lambs are lower than those of lambs born and reared in the spring. The extra wool produced by out-of-season lambing ewes will offset the decreased weaning weights of their lambs, but farmers will need to be rewarded with higher prices for out-of-season lambs to compensate for the lowered lamb production if they are to engage in out-of-season production systems.

5. The increased wool growth in June-lambing ewes compared to spring-lambing ewes may be partly explained by higher nutritional levels but there may also be seasonal effects independent of nutrition (such as altered endocrine status of the ewes). Future research into out-of-season lamb production should concentrate on the endocrine balance in the lactating June-lambing ewes in an attempt to explain, and develop methods of manipulating, some of the large seasonal differences in wool growth and lamb birth weights found in June-lambing ewes compared to August-lambing ewes.

6. During the last month of pregnancy, ewes lambing out-of-season can be continuously stocked on to very low SSH (2 cm) without affecting lamb birth weights or ewe wool production. Furthermore, lactating ewes can be continuously stocked at a SSH of 2-3 cm and maintain lamb liveweight gains, but at the expense of ewe liveweight and condition. This loss of liveweight and condition may not affect future production provided that the autumn/winter-lambing ewes are allowed to regain liveweight over the spring period. Where ewes are unable to regain this liveweight and/or are in poor condition at lambing, then higher SSH (4-6 cm), similar to those recommended for spring-lambing ewes, should be used. However, in terms of total efficiency of the system, allowing ewes to lose and then regain liveweight may be less efficient than maintaining ewes at a constant liveweight. There may also be a case for the differential stocking of out-of-season lambing ewes during lactation (ie the use of high stocking rates in early lactation but lower stocking rates as ewe and lamb intakes increase in later lactation). This opportunity to utilise ewe liveweight change may require a reconsideration of previous models that suggested a decreased stocking rate for ewes in out-of-season lamb production systems based on spring herbage allowance and SSH recommendations.

Finally, it is important to reiterate the point that, while the research encompassed in this thesis will aid in the development of systems for out-of-season lamb production, such systems will not be adopted by farmers until the price they receive for lamb reflects marketing realities. The New Zealand meat industry has traditionally adopted a conservative approach to the production and marketing of lamb. It is to be hoped that, in time, it will recognise the wisdom of these words:

> "Conservatism discards Prescription, shrinks from Principle, disavows Progress; having rejected all respect for antiquity, it offers no redress for the present, and makes no preparation for the future".

Benjamin Disraeli, Earl of Beaconsfield
1804-1881.

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APPENDIX I

Effect of sward height, cross and litter size on ewe digestible organic matter intake at four periods during lactation (Mean±SEM).

	No.	Digestible Organic Matter Intake (kg DOMI/ewe/d)			
		L13-L18[1]	L25-L28	L41-L44	L50-L50
Sward height (cm)					
2.6	10	1.7±0.1	1.5±0.1[a]	1.5±0.1[a]	1.5±0.1[a]
4.4	11	1.9±0.1	2.2±0.1[b]	1.5±0.1[a]	1.9±0.1[b]
7.8	11	1.9±0.1	2.6±0.1[c]	2.0±0.1[b]	1.7±0.1[ab]
Cross[2]					
BR	9	1.8±0.1	2.3±0.1	1.6±0.1	1.5±0.1
PBR	10	1.8±0.1	2.0±0.1	1.7±0.1	1.7±0.1
SBR	13	1.8±0.1	2.0±0.1	1.7±0.1	1.7±0.1
Litter Size					
1	16	1.6±0.1[a]	2.0±0.1	1.6±0.1	1.6±0.1
2	16	2.0±0.1[b]	2.2±0.1	1.7±0.1	1.7±0.1
Overall Mean	32	1.9±0.1	2.1±0.1	1.7±0.1	1.7±0.1

[1] L13-L18 refers to lactation d13 to d18 where L1=23 June.

[2] BR = Border Leicester x Romney, PBR = Poll Dorset x BR, SBR = Suffolk x BR.

[abc] Means with mainin effects and columns having superscripts with letters in common are not significantly different ($P>0.05$).

Addendum 1

(Requested by Examination Panel)

Mean wool production (kg) and weight of lamb weaned (kg) per ewe by policy, ewe age, cross and year and a sample calculation of the value of wool and lamb production. (Refer tables 3.16 and 3.17).

	June-lambing				August-lambing			
	2-year-old		3-year-old		2-year-old		3-year-old	
	Wool	Lamb	Wool	Lamb	Wool	Lamb	Wool	Lamb
BR[1]								
1987	4.8	25.8	-	-	4.1	31.3	-	-
1988	3.7	22.7	4.5	21.9	3.6	27.7	4.2	28.2
1989	5.7	22.0	4.9	28.9	4.5	27.5	4.0	32.9
1990	-	-	5.1	31.3	-	-	4.1	29.1
PBR[1]								
1987	4.1	31.0	-	-	3.6	33.6	-	-
1988	3.0	25.8	3.8	30.9	3.0	31.5	3.3	34.2
1989	4.2	21.1	4.1	27.1	3.5	34.6	3.3	37.3
1990	-	-	3.8	29.2	-	-	3.3	27.1
SBR[1]								
1987	3.6	30.5	-	-	3.3	31.9	-	-
1988	3.4	23.4	3.3	29.3	2.7	31.1	2.9	33.5
1989	4.2	23.4	3.9	24.8	3.4	28.6	3.2	38.8
1990	-	-	3.8	30.3	-	-	3.1	37.0

[1] BR = Border Leicester x Romney, PBR = Poll Dorset x BR, SBR = Suffolk x BR.

Sample calculation (BR 2-year-old June-lambing ewes in 1987).

Assumptions	1 kg greasy wool	= $3.00.
	1 kg lamb liveweight	= $0.66 for August-born lambs.
		= $0.88 for June-born lambs.

Value of wool = 4.8 kg x $3.00/kg = $14.40.
Value of lamb = 25.8 kg x $0.88 = $22.70.