The Effects of Pre-Lamb Shearing on Feed Intake, Metabolism and Productivity of Sheep

A thesis presented in partial fulfilment of the

requirements for the degree of

Doctor of Philosophy

in Animal Science

at Massey University

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1994

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الحمد لله رب العالمين
والصلاة والسلام على خاتم الأنبياء والمرسلين

In the Name of Allah,
the Compassionate, the Merciful,
Praise be to Allah, Lord of the Universe,
and Peace and Prayers be upon
His Final Prophet and Messenger.

ERRATA

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ABSTRACT

Dabiri, N. 1994: The Effects of Pre-Lamb Shearing on Feed Intake, Metabolism and Productivity of Sheep. PhD thesis, Massey University, Palmerston North, New Zealand. 182 pp.

The objective of this research programme was to investigate issues relating to the development of the pre-lamb shearing policy as a means of improving the productivity of, and financial returns to, New Zealand sheep farming systems. Four experiments were conducted with Border Leicester x Romney sheep to examine the potential advantages and disadvantages of pre-lamb shearing, and means of ameliorating the latter.

Experiment 1 compared the effect of pre-lamb and conventional (post-weaning) shearing by standard comb on the productivity of spring-lambing ewes (n= 250 per group) and their lambs under commercial conditions over 3 years. Ewes were shorn either about one month prior to lambing (during winter) or at weaning (during summer). Pre-lamb shearing was associated with a significant ($P<0.05$) increase in ewe fleeceweight and weaning weight in one year but not in the other (the first year being used to adjust ewes to the new shearing regimens. Shearing treatment did not affect lamb production (birthweight, weaning weight or growth rate).

In Experiment 2, a more detailed study was made of the effects of pre-lamb shearing, again by standard comb, in both spring (August)- and autumn (May)-lambing ewes (n = 30 per shearing x lambing policy group). Ewes in each policy were shorn on pregnancy day 118 (P118) or left unshorn until weaning. Pre-lamb shearing was associated with increased organic matter (OMI, 1739±58 vs 1526±59 g/d, $P<0.05$) and dry matter (DMI) intakes only at P141-144 (i.e. 2-3 weeks after shearing). Ewe liveweights and body condition scores, and lamb weights from birth to weaning, were unaffected by shearing treatment but back fat depths were significantly ($P<0.05$) lower in pre-lamb shorn ewes (4.3±0.2 mm) than in unshorn ewes (5.1±0.2 mm) on P142. The only parameter to exhibit a significant lambing policy x shearing treatment interaction was midside clean wool growth over P118-L (lactation day) 13, pre-lamb shorn May-lambing ewes producing significantly ($P<0.01$) greater clean wool weights than unshorn ewes (0.927±0.042 vs 0.721 ±0.048 mg/cm^2/day) whereas shearing was without effect in August-lambing ewes (shorn, 0.542±0.041 vs unshorn, 0.641 ±0.045 mg/cm^2/day, $P>0.05$).

The third experiment examined the potential benefits of pre-lamb shearing by cover comb. Ewes were shorn by cover comb or standard comb on P114 or left unshorn until weaning (n= 100/group). Despite similar post-shearing ewe survival rates and herbage intakes between ewes shorn pre-lamb by cover comb and unshorn ewes, standard comb-shorn ewes had greater losses (14 vs 3 %, P<0.05), OMI over P123-126 (1781±115 vs 1566±115 g/d, P<0.10) and biting rates (99.2±1.8 vs 93.7±1.8 bites/min, P<0.05) than cover comb-shorn ewes. Over the 20 days after shearing, only the standard comb-shorn group lost liveweight. Both pre-lamb shorn groups had greater (P<0.05) clean wool growth rates and superior (P<0.05) wool quality (yield and brightness) than unshorn ewes while lamb production and survival were similar between shearing treatments. Rectal temperature (RT) was significantly (P<0.05) lower in ewes shorn by the standard comb (38.9±0.08 °C) and cover comb (39.0±0.08 °C) than in the unshorn group (39.3±0.08 °C) on day 3 post-shearing (S3), but by S5 only the ewes shorn by the standard comb had lower RT. Generally, blood metabolite and hormone concentrations were different over the same time interval as RT, with circulating glucose and non-esterified fatty acid (NEFA) concentrations being elevated to the greatest extent in ewes shorn by standard comb.

Experiment 4 determined the effect of shearing by standard comb or cover comb on heat production and metabolism of non-pregnant, non-lactating sheep (8 pairs) in calorimetry chambers over 10 days post-shearing. Plasma NEFA concentrations and heat production (HP) were significantly greater in sheep shorn by standard comb than in those shorn by cover comb (a maximum difference in HP of 5.4 MJ/24h in wet, windy and cold conditions) while the reverse was true for body insulation and liveweight gain. This superior cold resistance in the cover comb-shorn group reflected their greater residual stubble depth (5.1±0.2 vs 3.1±0.2 mm).

The above results indicate that the effects of shearing treatment and lambing policy were additive in most respects, suggesting that the advantages and disadvantage of pre-lamb shearing spring-lambing ewes are also likely to apply to autumn- lambing ewes. The greater survival rate, rectal temperature and liveweight gain, but lower feed intake and heat production, of ewes shorn pre-lamb by cover comb than ewes shorn by standard comb, which reflected their greater residual stubble depth, clearly indicated that use of the cover comb should be strongly supported as a means of ameliorating the effects of pre-lamb shearing on cold stress and feed intake. A financial analysis of these results in a simulated sheep production system showed that pre-lamb shearing by cover comb could be expected to increase returns to the sheep farmer by approximately $1.26 per ewe compared with conventional post-weaning shearing. These increased returns were a consequence of both improved productivity and reduced overdraft charges for seasonal finance.

ACKNOWLEDGEMENTS

First of all praise be to Allah (God), The Lord of the Universe for giving me this opportunity to complete this difficult period and guiding my supervisors for their excellent supervision. Peace and Prayers also be upon the Final Prophet and all messengers and their Companions who were the righteous servants of God and consequently human beings.

This study programme was supervised by Professor Stuart McCutcheon, Dr Stephen Morris and Professor George Wickham of the Department of Animal Science, and Professor Warren Parker of the Department of Agricultural & Horticultural Systems Management, Massey University. I am particularly grateful for their enthusiastic support and expert supervision. I will never forget the patience of my chief supervisors (Professor Stuart McCutcheon and Dr Stephen Morris) for their constructive editing of draft scripts and assistance with the design and execution of my trials. I would like to acknowledge Professor Colin Holmes of the Animal Science Department as another (informal) supervisor and to express my grateful thanks for his friendly help in the field of climatic physiology and Experiment 4.

The excellent technical support for all field trials from Mr Dean Burnham and Mr Tim Harcombe in handling, collecting samples and recording data from sheep over a long period through difficult weather conditions, and also the help of Professor Max Wallentine of Utah University, USA (who was visiting the Animal Science Department over 3-4 months), are appreciated. Mr Kerry Kilmister and Mrs Lynley Free prepared and assisted with the management of livestock used for experiments in grazing conditions. Mr Barry Parlane provided friendly service with the running of the indoor experiment at the Animal Physiology Unit. The assistance of all of them is appreciated.

I would like to express my thanks to: staff of the Wool Laboratory for providing facilities for wool measurement; staff of the Nutrition Laboratory (particularly Mrs Kathy Morton and Mrs Barbara Purchas) for helping with the tedious task of digesting hundreds of faecal samples for chromium analysis; Miss Rosemary Watson for measuring chromium by atomic absorption spectrophotometry; and Mr David Hamilton for analysis of extrusa samples collected by oesophageal fistulated sheep for in vitro digestibility and fibre. Thanks are also due to Miss Margaret Scott, Miss Yvette Cottam and Ms Penny Back, staff of the Physiology Laboratory, for helping in collecting blood samples and analysing them for metabolites and hormones.

Thanks are extended to all staff of the Animal Science Department, particularly Dr Roger Purchas for measuring back fat depth of sheep and Dr Dorian Garrick for his statistical guidance.

The presence of all Iranian postgraduate students and their families in Palmerston North made my family and me feel at home. I wish a prosperous and happy future for all of them.

I would like to express my sincere thanks to the Ministry of Culture and Higher Education of Iran, for awarding me the scholarship to undertake this study.

I am particularly grateful to Mina, my wife, for her patience, considerable encouragement and loyal support during the last four years. Without her help this thesis would never have eventuated. Therefore this work is dedicated to her. The patience of my son Alireza and my daughters Maryam and Marzieh (Maedh), who suffered inadequate contact with their father for four years, is appreciated.

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AT	air temperature(s)
b	bite(s)
BFD	back fat depth
BI	body insulation
BLXR	Border Leicester x Romney
BR	biting rate(s)
BW	body weight
CIDR	Controlled Internal Drug Releasing device
cm	centimetre(s)
Cr_2O_3	chromic oxide
CRC	Contrroled Release Capsule
CS	condition score
CV	coefficient of variation
CW	clean wool
d	day(s)
P	day of pregnancy (e.g. P118 = day 118 of pregnancy)
L	day of lactation (e.g. L13 = day 13 of lactation)
S	day from shearing (e.g. S-2 = 2 days prior to shearing)
°C	degree(s) Celsius
°S	degree latitude South
D	digestibility
DM	dry matter
DMD	dry matter digestibility
DMI	dry matter intake
DOMD	digestible organic matter in dry matter
EPM	Ellinbank Pasture Meter
FD	fibre diameter
FO	faecal output
g	gram(s)
GW	greasy wool
GH	growth hormone
ha	hectare(s)
h	hour(s)
HFRO	Hill Farming Research Organisation
HP	heat production
I	intake
IU	International unit(s)
kg	kilograms(s)
l	litre

LCT	lower critical temprature
MJ	megajoules
ME	metabolisable energy
m	metre(s)
µg	microgram(s)
µm	micrometre(s)
mg	milligram(s)
meq	milliequivalent
ml	millilitre(s)
mm	millimetre(s)
mmol	millimol
Min	minimum
min	minute(s)
NEFA	non-esterified fatty acids
ng	nanogram(s)
N	nitrogen
OF	oesophageal fistulated
OM	organic matter
OMD	organic matter digestibility
OMI	organic matter intake
pg	picogram(s)
PMSG	Pregnant Mare Serum Gonadotropin
RT	rectal temperature(s)
SSU	sheep stock unit
SSH	sward surface height(s)
3OHB	3-hydroxybutyrate
s	second(s)
vs	versus
W	watts
Y	tristimulus value (green)
Y-Z	tristimulus value (yellow)
Z	tristimulus value (blue)

Statistical Terms

PSE	Pooled Standard Error of Mean
SEM	Standard Error of Mean
LSmean	Least Square of Mean
SELSM	Standard Error of Least Square Mean

CHAPTER ONE

INTRODUCTION

BACKGROUND

New Zealand farmers have an established reputation for being keenly interested in animal husbandry practices which may improve their production and financial circumstances (Everitt 1961). Even in times of low wool prices, wool commonly contributes more than 30% of the annual income of New Zealand sheep farmers (NZMWBES 1993). The management of wool harvesting is therefore an important determinant of sheep farming profit because of its effects on wool quality, sheep performance, labour requirements and cashflow (Parker & Gray 1989). The time and frequency of shearing can affect profitability, particularly through its effects on wool quantity and quality, and lamb production (Smith 1980). However, the choice of a suitable shearing policy depends on the unique attributes of each farm and farmer (Livingston & Parker 1984). Hence a system suiting one farmer may, for a variety of reasons, be entirely unsatisfactory for a neighbour. Although maximising income is an important factor in the choice of a shearing policy, other factors including additional work, increased risk, physical characteristics of the farm, requirements of the wool industry and interaction with other farm operations (e.g. sale of the wool clip, culling and the sale of surplus ewes, and the availability of labour) may conflict with the aim of increasing net returns. In New Zealand, increasing costs (particularly shearing costs) have lessened the impact of these non-financial factors and forced farmers to evaluate the profitability of alternative farming operations (Livingston & Parker 1984). Thus shearing policies which have lower costs, and are at the same time generating higher or comparable wool returns, have become more attractive.

In general, four shearing policies are carried out in New Zealand, namely: second shearing (two shearings per year); three shearings per two years (or an eight month shearing interval); pre-lamb shearing; and the most common, shearing once annually after weaning. Although the post-weaning shear remains the most common shearing policy, there has been a gradual shift towards other policies. Figure 1.1 shows these shearing policies and the corresponding patterns of wool growth rates (Henderson 1965).

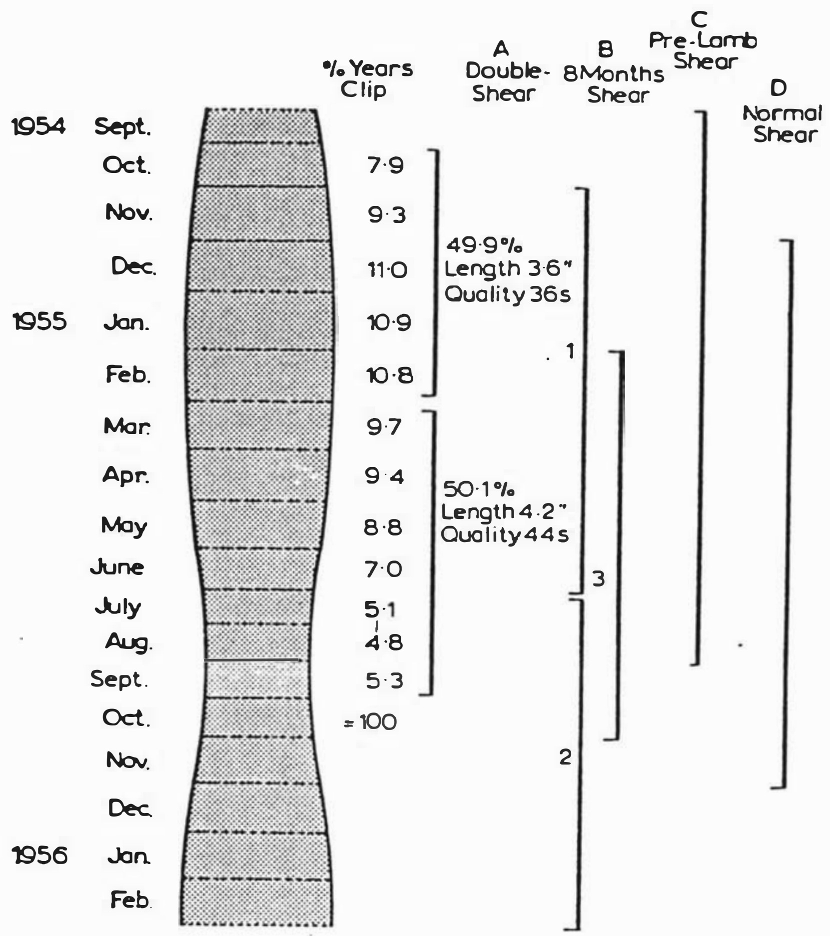

Figure 1.1 **Shearing policies in relation to wool growth in the majority of sheep breeds in New Zealand (Henderson 1965).**

Second-Shear Policy

This involves shearing twice a year (approximately over two periods, 5 months and 7 months) to clip equal amounts of wool at each shearing time. The advantages and disadvantages of this shearing policy have been discussed by Wodzicka-Tomaszewska (1963), Henderson (1965), Smith (1980) and Parker (1988). The advantages claimed for this policy are: increased wool production; better colour of wool; fewer oddments; reduced crutching and dagging; more active sheep and hence fewer becoming cast; improved lambing performance; and improved lamb growth. The main disadvantages are: shorter wool; additional shearing costs; higher feed requirements; and the greater risk of deaths from cold stress if shearing occurs in cold weather. Recently several trials have been conducted to quantify the differences between second-shear and traditional shearing policies (Parker 1984; Sumner & Willoughby 1985, 1988; Sumner & Armstrong 1987). In spite of confirming most of the abovementioned advantages, these trials showed that, overall, net wool returns were superior for once-shorn ewes.

Eight-Month Policy

The eight-month shearing policy has been reviewed by Henderson (1965) and Livingston & Parker (1984). The problems and advantages of this shearing policy are similar to those of the second shearing policy. However, it provides two additional benefits compared with the second shearing policy, namely a reduction in shearing costs and improved wool staple length. The complication of several shearing times and the imbalance of wool income between years are obvious disadvantages.

Pre-Lamb Shearing

Pre-lamb shearing was first adopted in the 1930's when farmers in South Otago and Southland shifted shearing once-yearly from the conventional November/ December (post-weaning) period to shearing pregnant ewes in August (pre-lambing). Pre-lamb shearing became more widely practiced from the 1950's onwards and by the 1960's about 25% of South Island breeding ewes and a few flocks in the North Island were shorn under this policy (Henderson 1965). However, although pre-lamb shearing was adopted initially on the high country for convenience, it was then found to have other benefits, particularly through earning a premium for pre-lamb shorn wools.

The benefits and problems of pre-lamb shearing policies have been discussed by several authors (Coop 1950; Story 1955; Wodzicka-Tomaszewska 1963; Frengley 1964; Henderson 1965; Livingston & Parker 1984). The advantages claimed for this policy are: increased lamb survival and decreased frequency of cast ewes; improved wool returns due to increased wool quality and quantity, and reduction of shearing costs; greater birthweight and growth rates of lambs; and improved flock management. The disadvantages are increased ewe feed consumption and the risk of high ewe losses from cold stress. There is, however only limited experimental evidence from New Zealand trials to support most of the above claims.

Because the lambing period in New Zealand occurs in late winter or early spring, pre-lamb shearing coincides with mid to late winter. Therefore, pre-lamb shorn ewes may encounter cold, windy and wet weather which is likely to induce cold stress. Cold has marked effects on freshly shorn sheep (Hutchinson & Bennett 1962; Slee 1985). The effects of cold on pregnant sheep may change ewe and lamb productivity. These differences in productivity between shorn and unshorn ewes may reflect increased feed intakes which in turn are related to changes in physiological and digestive function and heat exchanges (Blaxter et al. 1959a,b; Blaxter 1962; Alexander 1974b, 1979; Young 1983; Kennedy 1985; Sasaki & Weeks 1986; Slee 1987).

ADVANTAGES OF PRE-LAMB SHEARING

Wool Quantity

Variable effects of pre-lamb shearing on wool growth rate and annual fleeceweight have been reported in the literature. Story & Ross (1960) found inconsistent differences in wool production between ewes shorn pre-lamb and post-weaning when monthly wool growth rates were measured on both shearing groups. Similar annual fleeceweights were recorded for both shearing policies by Sumner & Scott (1990) when they compared ewes shorn pre-lamb in July with ewes shorn post-weaning in January. On the other hand a greater fleeceweight was recorded for pre-lamb shorn ewes than for their post-weaning December-shorn counterparts by Everitt (1961).

Wool growth is known to be influenced by several factors including season, particularly day length (Coop 1953; Coop & Hart 1953; Hart 1955, 1961; Bigham et al. 1978; Geenty et al. 1984; Hawker 1985), nutrition (Allden 1979; Hawker et al. 1984; Bigham 1986; Williams & Butt 1989), ambient temperature (Wodzicka-Tomaszewska 1960a,b) and physiological state (Corbett 1979; Hawker & Thompson 1987; Parker et al. 1991). Inter-relationships between these factors may be the cause of inconsistencies between experiments addressing effects of pre-lamb shearing on wool growth rate. For example, exposure of ewes to temperatures below the lower critical temperature, which is expected to occur for pre-lamb shorn ewes in the New Zealand winter/spring, can increase feed intake (Blaxter et al. 1959b; Wheeler et al. 1963; Wodzicka-Tomaszewska 1963; Elvidge & Coop 1974) which in turn could increase wool growth rate. Furthermore, because of the increase in rate of passage of digesta from the reticulo-rumen in shorn sheep exposed to cold weather, more dietary protein escapes rumen fermentation which in turn can increase the intestinal protein flow (Kennedy & Milligan 1978; Christopherson & Kennedy 1983; Ngongoni et al. 1984; Young 1987). This might also cause higher growth rates of wool in pre-lamb shorn sheep. Conversely, the occasionally severe cold weather experienced by ewes immediately after shearing may decrease the wool growth rate for a short period. Graham et al. (1959) indicated that maximum wool growth rate for the first week after shearing occurred at around 28°C ambient temperature, but wool growth decreased 30% when the temperature fell to 13°C. They concluded that wool growth immediately after shearing is related to ambient temperature. Severe cold stress, by decreasing skin blood flow (Hopkins & Richards 1979) and increasing glucocorticoid secretion (Wallace 1979), can reduce the rate of wool growth. However, it is known that a high level of nutrition can increase the cold resistance of sheep. Thus the effects of these various factors on wool growth rate post-shearing are likely to be strongly influenced by the environmental conditions to which shorn ewes are exposed and the level and quality of feed available to them.

Wool Quality

Shearing time can affect wool quality because of the marked seasonal pattern of wool growth in long-woolled breeds of sheep in New Zealand (as shown in Figure 1.1), and seasonal variation in the climatic conditions to which sheep are exposed. Wool yield, strength and colour are all affected by timing of shearing. While yield has a limited impact on wool value, processing trials have shown that the most important wool characteristics which affect yarn manufacture are staple length, staple strength, and extent of unscourable discolouration (Sumner 1986).

Yield

It was shown in several studies that the yield of wool is greater for pre-lamb shorn ewes than for ewes shorn post-weaning (Coop 1950; Story 1955; Story & Ross 1960; Henderson 1965). Story (1955) and Story & Ross (1960) found that the greater yield in the wool of pre-lamb shorn ewes was caused by a lower level of suint.

Strength

Ross (1960 ,1984) reported that the staple strength of wool from pre-lamb shorn ewes was 2.0 to 2.7 times greater than that of wool from conventionally shorn ewes. Pre-lamb shearing not only results in the production of a stronger fibre/staple, but also has been found to be much superior in wool soundness and freedom from wool faults such as tenderness and cotting (Story & Ross 1959, 1960). Although all wools suffer some degree of fibre breakage during processing, particularly in modern high-speed processing machinery, sound wools generally result in less breakage compared with tender wools (Ross et al. 1960; Von Bergen 1963; Bratt et al. 1964; Ross 1982). Tenderness is a serious fault of wool, particularly in New Zealand crossbred sheep, and tender fleeces often have other associated problems such as cotting and yellow discolouration (Bigham et al. 1983). Cotting can result in damage to processing equipment (Ross 1978; Bell 1981) and consequently there is a marked price discount for cotted wool (Joyce 1961; Wickham 1973; Wickham & Bigham 1976; McPherson 1982).

Wool strength is related to the seasonal wool growth rate and associated changes in fibre diameter. As shown by Hawker & Crosbie (1985), ewes produce wool of higher fibre diameter and greater length growth rate in the summer than in the winter (by 5.5 μm and 0.15 mm per day respectively). Also as shown in Figure 1.1, and by Story & Ross (1960), both the length grown per day and the diameter vary in an annual cycle, and their minimum rates occur in the winter-early spring (July-August). Therefore shearing in winter, when the fibre of lowest diameter is near the skin level, will result in a stronger fibre than shearing in summer when the minimum fibre diameter is about half way up the staple (Bigham et al. 1983). From the manufacturer's point of view it is desirable that the weakest point be at the ends of the fibre (Ross et al. 1960; Bratt et al. 1964; Sumner 1985).

Colour

It was shown by Story (1955) and Story & Ross (1960) that yellowness of wool is reduced and brightness of wool is improved in pre-lamb shorn ewes compared with conventionally shorn ewes. Henderson (1965) suggested that the shorter wool of pre-lamb shorn ewes was more readily washed of substances causing yellow discolouration than the longer wool of later shorn ewes during the wet and warm conditions that are typical of spring. Thus shearing as early as practical in the spring minimises colour faults in the wool (Henderson 1965; Sumner et al. 1982). Discolouration affects the dyeing characteristics of wool, and is therefore a significant factor in determining its value (Hoare 1974; McPherson 1982).

Lamb Production and Survival

Several pre-lamb shearing experiments, particularly those conducted on housed pregnant ewes, have shown that the birthweights and/or growth rates of lambs born to ewes shorn before lambing are greater than those of lambs from unshorn ewes (Maund 1980; Salman & Owen 1986; Symonds et al. 1986; Vipond et al. 1987; Phillips et al. 1988; Black & Chestnutt 1990). Other studies, including those conducted with pasture-fed ewes, have failed to show such an effect (Russel et al. 1985; Orleans-Pobee & Beatson 1989; Sumner & Scott 1990; Parker 1991). This inconsistency between experiments may be related to the environmental conditions and their effects on maternal metabolism and feed intake, and to the time of shearing in relation to lambing date.

Shorn animals managed under grazing conditions in a temperate to cold climate (similar to the New Zealand climate) are less able to increase feed intake, in response to shearing than those managed under intensive conditions. It is therefore interesting to note that, when food allowance was restricted for both pre-lamb shorn and unshorn housed ewes, the birthweights and growth rates of single or twin lambs to 14 weeks of age were not affected by shearing treatment (Russel et al. 1985). The fact that ewes in the New Zealand studies (Orleans-Pobee & Beatson 1989; Sumner & Scott 1990; Parker et al. 1991) were shorn four weeks pre-lambing, rather than the six or more weeks as in other studies (Maund 1980; Symonds et al. 1986; Vipond et al. 1987; Salman & Owen 1986; Black & Chestnutt 1990), could also account for the lack of an effect of shearing on birthweights. This is supported by the study of Black & Chestnutt (1990) who examined the effect of time interval from shearing to lambing in housed pregnant ewes (shorn 12, 9, 6 and 4 weeks before lambing) and recorded a considerable increase in birthweights of lambs only from those sheep shorn at least 6 weeks before lambing. Furthermore, a lower mean gestation length (2-3 days), accompanied by higher respiration rates and rectal temperatures in unshorn ewes compared with shorn ewes in some studies (Murray & Crosby 1986; Vipond et al. 1987; Black & Chestnutt 1990), suggests that the lower birthweights of lambs born to unshorn ewes in those studies reflect a shorter period of foetal growth due to effects of maternal heat stress (Shelton & Huston 1968; Alexander & Williams 1971; Austin & Young 1977). Thus the greater birthweights of lambs born to pre-lamb shorn ewes in overseas studies are likely to reflect the combined effects of alleviation of maternal heat stress, increased ewe feed intake, and the relatively longer period between shearing and lambing.

Greater birthweights of lambs born to pre-lamb shorn ewes, if achievable under New Zealand conditions, could potentially improve lamb survival (Hinch et al. 1985) due to a greater ability of heavy lambs to maintain heat production relative to heat loss in cold conditions (Alexander 1974a, 1986; Moore et al. 1986; Robinson 1990). This could be an important advantage of pre-lamb shearing under New Zealand farming conditions since lamb losses are typically between 15 and 25% of all lambs born and one- third of these losses are due to the starvation/exposure syndrome (McCutcheon et al. 1981). The fact that the pre-lamb shorn ewes have a greater tendency than unshorn ewes to lamb in sheltered positions away from the wind and rain (Alexander & Lynch 1976; Done-Currie 1980) would lead one to expect an increased survival in lambs born to pre-lamb shorn ewes. However, this beneficial effect of pre-lamb shearing on lamb survival may not be apparent on the flatter paddocks typically used for experiments. This could be the reason of the lack of a marked effect of pre-lamb shearing on lamb survival in the few pre-lamb shearing experiments conducted in New Zealand (Everitt 1961; Sumner & Scott 1990). Furthermore, in none of the New Zealand experiments did shearing occur within a week of lambing. Alexander & Lynch (1976) indicated that lamb survival is improved by shearing ewes a week or so before lambing, presumably because the high level of cold-stress experienced by freshly shorn ewes encourages them to seek shelter.

Farm Management Parameters

In comparison with the conventional post-weaning shearing policy, several management advantages have been suggested for a pre-lamb shearing policy in New Zealand (Coop 1950; Frengly 1964; Parker & Gray 1989). These include: a reduction in labour requirements and improved spread of labour requirements for sheep work; increased flexibility with operations such as weaning and sale of wet-dry ewes; lower shearing costs through the elimination of pre-lamb crutching; better availability of shearers; reduction in competition with other farm activities (e.g.haymaking, harvesting, cultivation and sowing operations which often coincide with conventional shearing); less wool lost from ewes that die over lambing; a lower incidence of ewe casting; and reduced overdraft charges for seasonal finance. Similar advantages for winter pre-lamb shearing in Tasmania have been reported by Bottomley & Hudson (1976). In spite of these advantages, the risk of ewe losses through post-shearing cold stress and the need to supply additional pasture to meet the extra feed demand of pre-lamb shorn ewes are considered likely disadvantages of this policy.

DISADVANTAGES OF PRE-LAMB SHEARING

Feed Intake Responses of Shorn Sheep

In cold weather, the animal's pelage provides substantial thermal protection by reducing convective and conductive heat exchange (Young 1987). It was shown in several studies, but not in all studies, that shearing of sheep was associated with increases in feed intake (Coop & Drew 1963; Wheeler et al. 1963; Wodzicka-Tomaszewska 1963,1964; Webster & Lynch 1966; Elvidge & Coop 1974; Love et al. 1978; Maund 1980; Morgan & Broadbent 1980; Salman & Owen 1986; Vipond et al. 1987; Black & Chestnutt 1990; Parker et al. 1991). In spite of this trend, changes in feed intake following shearing are extremely variable, ranging from virtually no increase in some experiments (Moose et al. 1969; Minson & Ternouth 1971) to small increases in some studies (e.g 10-20%, 1970; Weston 1970; Black & Chestnutt 1990; Parker et al. 1991) to large increases (20-78%) in others (Wheeler et al. 1963; Wodzicka-Tomaszewska 1963,1964; Hutchinson & McRae 1969; Elvidge & Coop 1974; Weston 1982). The magnitude of feed intake responses is probably related to the climatic conditions following shearing (Joyce 1968; Elvidge & Coop 1974), availability of feed (Coop & Drew 1963), types of diet (Minson & Ternouth 1971; Black & Chestnutt 1990) and adaptation to cold (Sykes & Slee 1969; Webster 1974; Young 1985).

In the majority of the abovementioned studies, feed intake responses to shearing were measured in non-pregnant sheep or in housed pregnant sheep. Responses of feed intake in these two groups of sheep will not necessarily be similar to the feed intake changes of pre-lamb shorn ewes at grazing. The lower heat production in non-pregnant ewes compared with pregnant ewes may lead to increased feed intake in former group, but not in latter group, because of differences in their lower critical temperature. Thus it is estimated that the resting heat production (RHP) is 345 KJ/kg$^{0.75}$/d and the lower critical temperature (LCT) is 25°C in non-pregnant shorn ewes versus 644 KJ/kg$^{0.75}$/d and 2°C respectively in pregnant shorn ewes. In adult lactating shorn ewes the RHP and LCT are 808 KJ/kg$^{0.75}$/d and -8°C respectively (Christopherson & Young 1986). Because of the greater feed intake and resting heat production of pregnant and lactating animals, shearing may not have as large an effect on feed intake as with non-pregnant ewes. This explanation is supported by the results of a Tasmanian experiment, in which the effect of winter shearing on feed requirements of dry and pregnant (13-20 weeks) ewes was compared (Hudson & Bottomley 1978). It was shown that, over the 8 weeks after shearing, the increase in maintenance requirements was 47% in dry ewes, but only 15% in pregnant ewes. Likewise the greater feed intake in pregnant shorn ewes compared with unshorn ewes under housing may be related not to the effects of cold stress after shearing, but rather to the removal of a heat load due to the reduction in fleece insulation (Russel et al. 1985; Salman & Owen 1986; Black & Chestnutt 1990).

During last month of pregnancy in ewes, intake does not rise to match the increasing demands of pregnancy, particularly under grazing conditions (Weston 1979; Weston & Poppi 1987). Rather, intake is more likely to decline (Weston 1982) and a marked decrease in intake is consistently observed in the last few days of pregnancy (Weston & Poppi 1987). This is a consequence of metabolic changes in the ewe, and of changes in rumen volume due to increasing size of the conceptus, and may also limit the ability of pre-lamb shorn ewes, particularly those shorn in late pregnancy, to exhibit feed intake responses.

Although the energy requirement for maintenance increases as soon as the sheep is shorn, studies of voluntary feed intake after shearing indicate that it does not increase immediately but rather increases steadily, reaching a peak in about 3-4 weeks and then declining (Wodzicka-Tomaszewska 1963, 1964; Webster & Lynch 1966; Weston 1970; Donnelly et al. 1974; Hawker et al. 1985; Phillips et al. 1988). This suggests that sheep cannot increase their voluntary intake rapidly to meet the increase in energy requirement immediately after shearing in cold conditions. Therefore it has been suggested by Faichney et al. (1976) that, when shearing is expected to be followed by cold conditions, the plane of nutrition should be increased as much as possible for a few weeks prior to shearing.

In addition to the effects of shearing-induced cold-stress on feed intake, there is evidence of an effect of cold on the ability of animals to digest their feed. Thus several studies, conducted mainly with dry sheep, have shown that cold-stress reduces digestibility, (Blaxter et al. 1959b; Christopherson 1976; Kennedy et al. 1976; Westra & Christopherson 1976; Kennedy et al. 1977; Kennedy & Milligan 1978; Nicholson et al. 1980; Kennedy et al. 1982; Christopherson 1985) although the magnitude of the effect appears to depend on the nature of the feed (Minson & Ternouth 1971; Kennedy et al. 1982; Christopherson & Kennedy 1983). This effect, which apparently occurs as a result of increased rates of passage of digesta through the gastrointestinal tract (Kennedy et al. 1976; Westra & Christopherson 1976; Kennedy et al. 1977; Kennedy & Milligan 1978; Kennedy et al. 1982; Weston 1982; Christopherson & Kennedy 1983; Kennedy 1985; Kennedy et al. 1986), is likely to place pre-lamb shorn ewes under additional nutritional stress.

Grazing behaviour

Animals adjust their behaviour to avoid unpleasant situations. Hutchinson & McRae (1969) have reported reduced night-time grazing in newly shorn sheep during cold weather. This response was presumably to minimize night radiation efflux of body heat. It was also shown that the time spent standing was greater in shorn ewes than in unshorn ewes, both in grazing conditions (Hutchinson & McRae 1969; Done-Currie 1980) and in a calorimetry respiration chamber (Davey & Holmes 1977). This change in behaviour made a large contribution to the increase in energy expenditure after the sheep were shorn (Davey & Holmes 1977). Only a small increase in grazing time for shorn vs unshorn ewes has been reported (Webster & Lynch 1966; Hutchinson & McRae 1969) indicating that the increased feed intake after shearing results mainly from an increased rate of feeding (Hutchinson & McRae 1969). A reduction of grazing time on the coldest days after shearing has been reported by Webster & Lynch (1966).

Ewe Survival

The claim that pre-lamb shearing of ewes during winter may reduce their survival is based on the fact that, in the closely shorn sheep with a residual fleece depth of a few millimeters, low ambient temperatures, wind and wetting of the coat have marked effects on heat loss (Graham et al. 1959; Bennett & Hutchinson 1964; Joyce & Blaxter 1964). Thus, in a wetted sheep (fleece about 7 mm deep) exposed to 15°C ambient temperature and a wind of 7 m/s (25 km/h) heat production is about 350 W/m^2 while, in a well fleeced sheep exposed to similar conditions, metabolic rate would be scarcely 100 $W\ m^{-2}$. Furthermore, although it has been shown that the lower critical temperature (LCT) of an animal is affected by many factors, including breed, climate (ambient temperature, air speed and rain) and nutrition, the depth of fleece also has a marked effect on LCT. Tables 1.1 and 1.2 illustrate the effects of some of these factors on LCT or heat production in sheep.

Table 1.1 The critical environmental temperature of sheep[1]

Type of sheep	Critical temperature (°C)
Adult sheep:clipped, fasted	30
Adult sheep:clipped, maintenance fed	25
Adult sheep:clipped, high plane fed	13
Adult sheep:2.5cm fleece, maintenance fed	13
Adult sheep:12cm fleece, maintenance fed	-04
Adult sheep:20-30cm fleece, high plane fed	-20

[1] From Blaxter et al. (1966) and Alexander (1974b).

Table 1.2 Changes in the mean metabolism (HP, kcal/24h) of five breeds of sheep on exposure to low air temperatures, wind (W) and rain (R)[1]

Breed	No. of sheep	HP in cold room	Increase due to		
			W 4.5m/s	R	R+W
Scottish Blackface	3	1014	+332	+849	+1211
Welsh Mountain	2	984	+341	+928	+1000
Cheviot	3	1549	+325	+1534	+2109
Suffolk Down	4	1268	+212	+789	+1358
Hampshire Down	4	1196	+58	+721	+863

[1] From Blaxter et al. (1966).

The effect of cold stress on shorn sheep may be explained by considering the relationship between the cold lethal limit and summit metabolism. The maximum metabolic rate (summit metabolism) of adult sheep is widely variable and, under particular conditions, heat loss may exceed summit metabolism with the result that animals die of hypothermia (Alexander 1974b). It was shown by Bennett(1972) that freshly shorn sheep with an average fleece depth of 7 mm would not become hypothermic until air temperature fell below -50°C in dry still air conditions. However, with a wind of 7 m/s and the fleece saturated with water, sheep would become hypothermic at ambient temperatures below 13°C. A similar result was shown by Alexander (1979), see Table 1.3. On the other hand it was shown by Bennett (1972) that sheep with a fleece depth of 100 mm can tolerate windy and wet conditions until ambient temperature reaches -70°C.

Table 1.3 Summit metabolic rate of adult shorn sheep and different environmental temperatures (°C) at which heat loss equals maximum heat production and below which thermoregulation would fail[1]

Body weight (kg)	Summit metabolism (W)	Still air dry fleece	Wind (20-25km/h) dry fleece	Wind (20-25km/h) wet fleece
25	260	-45	-5	15
50	493	-62	-14	10

[1] From Alexander (1979).

In practice, and despite the relatively cold winter conditions in New Zealand, greater losses of pre-lamb shorn ewes compared with unshorn ewes have not been reported (Everitt 1961; Sumner & Scott 1990). Hutchinson & McRae (1969) reported high losses, of 21 to 24 %, for adult Merino wethers following conventional shearing when adverse climatic conditions were encountered during a 12-day period after shearing. Differences in breed and physiological state between the sheep in the experiment reported by Hutchinson & McRae (1969) and those in the two pre-lamb shearing experiments carried out in New Zealand may explain the different results. However, a more likely explanation is that climatic conditions were more adverse immediately after shearing in the study of Hutchinson & McRae (1969) than in the New Zealand studies. That is, the extent to which pre-lamb shearing leads to increased ewe losses will depend very much on the environmental conditions to which ewes are exposed shortly after shearing.

Ewe Liveweight and Condition Score

It has been shown that pre-lamb shorn ewes lose more liveweight or gain less liveweight during late pregnancy (post-shearing) than unshorn ewes (Elvidge & Coop 1974; Hudson & Bottomley 1978). Symonds et al. (1986, 1989) indicated that metabolic adaptations in shorn ewes, as a result of chronic cold exposure in late pregnancy, stimulate the mobilization and oxidation of maternal fat reserves to support the higher rate of thermoregulatory heat production. Therefore the lower liveweight of shorn ewes compared with unshorn ewes after shearing is consistent with a greater heat expenditure and consequently greater lipolysis of body fat depots in the shorn group.

Salman & Owen (1986), Black & Chestnutt (1990) and Parker et al. (1991) indicated that pre-lamb shearing treatment during pregnancy had no significant influence on weight change or condition score during early lactation, presumably because regrowth of the fleece had minimised differences between the groups in cold stress by that time.

PRE-LAMB SHEARING AND OUT OF-SEASON LAMBING

Most breeds of sheep have clearly defined breeding and non-breeding seasons with photoperiod being a primary environmental cue (Haresign & McLeod 1985). In New Zealand there is a marked seasonal change in reproductive activity, with peak ovulation rates in April and the first half of the May (Avrill 1964). Therefore the normal lambing coincides with early spring. The mating of ewes in the non-breeding season, induced by a variety of techniques, leads to "out-of-season lambing", most commonly in autumn or winter. The importance of out-of-season lambing will be clear if the relatively short length of the New Zealand lamb killing season in comparison with that of its competitors is considered (Taylor 1982). If New Zealand sheep meat is to compete more effectively in international markets, the sheep industry will have to evolve a more even year-round production system through the use of out-of-season lambing. Although research efforts have concentrated on the development of out-of-season lambing systems (Andrewes & Taylor 1986; Taylor & Andrewes 1987; Reid et al. 1988; Morris et al. 1993a,b, 1994a), the optimum shearing policies for these systems have not been considered in detail.

Because the environmental conditions (eg. climate, pasture supply) differ in normal and out-of-season lambing, the effect of pre-lamb shearing may differ between these two lambing policies. As described earlier, the risk of cold stress and increased feed intake after shearing are the main disadvantages of pre-lamb shearing associated with the normal spring lambing. These factors may be less important when associated with out-of-season lambing, because the shearing time (March/April) would coincide with autumn when the climate is more favourable than in winter.

The responses of wool production to pre-lamb shearing may be better in autumn than in winter, because of better climatic conditions and greater feed availability as discussed above. It has been shown in several studies that autumn-lambing ewes have a greater total annual fleeceweight than spring-lambing ewes (Reid et al. 1988; Reid & Sumner 1991; Notter & McClaugherty 1991; Morris et al. 1993a). Likewise, autumn-lambing ewes produce a more even pattern of wool growth rate than spring-lambing ewes and have a superior fibre diameter, strength and colour (Reid et al. 1988; Reid & Sumner 1991; Morris et al. 1994a).

The greater pasture availability and warmer climate during autumn compared with late winter and early spring in New Zealand should, at least in theory, provide a greater opportunity for ewes pre-lamb shorn in an autumn-lambing policy to increase herbage intake than for ewes pre-lamb shorn in a spring-lambing policy. This could in turn leads to greater responses in wool growth and lamb birthweight among ewes pre-lamb shorn in the autumn. However this is yet to be tested experimentally.

COVER COMB SHEARING

As discussed earlier, both LCT and heat production are affected markedly by post-shearing stubble length due to changes in external insulation. Joyce & Blaxter (1964) have shown that the external insulation of the sheep increases linearly with fleece depth over the range 5-50 mm. Thus shearing sheep by cover comb (which leaves 5-7 mm of stubble vs 2-4 mm with a standard comb) should increase the cold resistance of animals in adverse weather conditions and so reduce feed intake responses and/or the extent to which body reserves must be mobilised to support increased heat production.

Little work has been done to examine the potential benefit of pre-lamb shearing ewes by cover comb. However, the results of a calorimetry trial with non-pregnant sheep indicated that, in the absence of wind or rain, cover comb-shorn sheep were more resistant to cold conditions (10°C ambient temperature), particularly 3 days after shearing (Holmes et al. 1992). Lower heat production/heat expenditure in ewes shorn by cover comb than in ewes shorn with a standard comb (Holmes et al. 1992) should allow a greater proportion of absorbed nutrients to be partitioned towards wool production and/or foetal growth. Ewes shorn with a snow-comb exhibited greater rectal and skin temperatures, and lower heart rates, than ewes shorn with a standard comb when both groups were exposed to cold and windy conditions for 18-20 hours after shearing (Hutchinson et al. 1960). In that experiment, 7 of the 8 standard comb-shorn animals, but only one animal from the other group, had to be removed from the climatic treatment on account of hypothermia or weakness. It was shown that the insulation in sheep shorn by snow-comb with residual wool of 0.5 inches (12 mm) was double that of standard comb-shorn sheep with residual wool of 0.2 inches (Hutchinson et al. 1960). None of above experiments was, however, performed in cold, windy and wet conditions. It is likely that the magnitude and duration of superior cold resistance in cover comb-shorn ewes would be increased by exposure to more extreme cold conditions. The effects of cover comb shearing on mortality of newly-shorn sheep have not been investigated and, because pre-lamb shearing of ewes may be associated with an adverse climate after shearing in New Zealand conditions, the comparative effects of different shearing methods on ewe feed intake, productivity, and survival require examination.

PURPOSE AND SCOPE OF THE INVESTIGATION

As indicated earlier, the choice of shearing policy can have significant effects on profitability of sheep farming enterprises. Pre-lamb shearing is claimed to have several advantages, but has been the subject of only limited study under pastoral conditions. The objective of this study was therefore to address several issues relating to the effects of pre-lamb shearing and, in particular, to examine:

1. Effects on ewe fleece production and quality.

2. Effects on ewe feed intake, liveweight change and lamb production.

3. Whether pre-lamb shearing has differential effects on productivity under autumn- vs spring-lambing policies.

4. The possible benefits of cover comb-shearing as a means of minimising some of the potential disadvantages of pre-lamb shearing.

Studies were conducted both in the field and using calorimetry chambers.

CHAPTER TWO

EFFECTS OF PRE-LAMB AND CONVENTIONAL FULL-WOOL SHEARING ON THE PRODUCTIVITY OF, AND FINANCIAL RETURNS FROM, EWES

ABSTRACT

The effects of pre-lamb and conventional (post-weaning) annual shearing of ewes on their productivity, management inputs, and financial returns were studied over a three year period.

Ewes (n=500) were selected from a flock of 5000 mixed-age Border Leicester x Romney ewes at Massey University's Riverside property in the Wairarapa in April 1989 and randomly allocated into two equal sized groups. Both groups were managed under the same conditions until December 1991. Throughout the trial, one group was shorn after weaning in November/December and the second group was shorn prior to lambing in August. Ewe liveweight and lambing performance were measured over three years, and individual ewe fleeceweights were recorded over two full years.

Pre-lambing ewe liveweights were similar for both policies in all years, while post-weaning liveweights were greater in pre-lamb shorn ewes in 1989 only. Annual fleeceweights were significantly ($P<0.05$) greater for the pre-lamb shorn ewes in 1990 (4.07 ± 0.05 vs 3.64 ± 0.06 kg) but not in 1991 (3.61 ± 0.08 vs 3.75 ± 0.09 kg). Lamb birth weights, survival of lambs born to docking, weaning weights and ewe losses did not differ between shearing treatments. The small difference in ewe and lamb

performance between the shearing treatments suggests that management factors, such as the provision of feed and shelter post-shearing, the spread of seasonal work, net income per ewe and cashflow, should determine whether a pre-lamb shearing policy is adopted.

INTRODUCTION

During the early 1980's a number of New Zealand sheep farmers adopted shearing policies that involved shearing crossbred ewes once-yearly in preference to shearing twice per year. Livingston (1983) suggested that the rising cost of shearing (e.g. $62 per 100 ewes in 1978 to $128 per 100 ewes in 1983) and the increasing price margin between long- and short-stapled wools were the main reasons for implementing this change. Several trials have been conducted to quantify the differences between twice-yearly (second shorn) and once-yearly (full wool) shearing policies (Parker 1984; Sumner & Willoughby 1985, 1988; Sumner & Armstrong 1987). These trials showed that, despite advantages to the second-shorn ewes of greater clean wool production and colour, and a small improvement in lambing performance in some years, overall net wool returns were superior for once-shorn ewes. However, farm profit, when sheep survival and other factors were accounted for, was similar for both policies.

In none of the above experiments was pre-lamb shearing of ewes examined as a once-yearly shearing option. The wool of pre-lamb shorn ewes is likely to provide high net returns because of better colour (Story 1955) and greater staple strength, due to wool harvesting occurring at the optimum time in relation to the pattern of fibre growth (Ross 1960; Sumner 1985). Also, several trials in the United Kingdom have shown that the lambs of housed pre-lamb shorn ewes are heavier at birth and grow more rapidly than lambs produced by unshorn ewes (Symonds et al. 1986; Vipond et al. 1987; Black & Chestnutt 1990). As discussed in Chapter 1, reducing lambs losses 15-25% of lambs born (McCutcheon et al. 1981) could be an important advantage of pre-lamb shearing under New Zealand farming conditions. These potential advantages of pre-lamb shearing (at the end of winter or early spring in August-October) are offset by the risk of increased ewe losses post-shearing from cold stress (Everitt 1961) and a shortage of pasture relative to the increased feed demand of ewes post-shearing (Coop & Drew 1963; Joyce 1968; Parker et al. 1991). With respect to the latter, ewe feed intake may increase by up to 78% depending on weather conditions and this increase in intake may persist for 4 to 6 weeks (Elvidge and Coop 1974), although at a progressively diminishing level as the wool regrows.

The limited published evidence describing the effects of a pre-lamb shearing policy under New Zealand farming conditions prompted the experiment described in this Chapter, in which the effects of once-yearly shearing of ewes in August (prior to lambing) and in November/December (conventional full-wool policy) were compared. The experiment was conducted under commercial farming conditions in the Wairarapa region of New Zealand over a three year period.

MATERIALS AND METHODS

Experimental Design and Animals

The 500 experimental ewes were selected from a flock of 5000 mixed age Border Leicester x Romney ewes at Massey University's Riverside property in the Wairarapa (latitude 39°S) in April 1989. The 500 ewes, which had been marked by crayons fitted to rams during the first 10 days of 1989 mating, were randomly allocated into two equal sized groups. Ewes were individually eartagged to identify "conventional" and "pre-lamb" shearing groups. Throughout the trial, "conventional" ewes were shorn after weaning in November/December and "pre-lamb" ewes were shorn 3 to 4 weeks prior to the commencement of lambing in August. Only the conventionally shorn ewes were crutched prior to lambing.

General Management

The trial was run under the usual sheep management system for Riverside (Parker 1987) and measurements coincided with the normal sheep farm operations at shearing, docking, weaning and mating. Both groups of ewes were grazed together for the duration of the experiment, except for the period beginning at set-stocking for lambing (late August) and ending at docking (mid-October, when the lambs were 5 weeks of age). During this period each shearing group was continuously stocked in paired paddocks to minimize environmental effects. All of the experimental animals were rotationally grazed with the full commercial flock from weaning until the following lambing (August). Farm pasture cover information was collected at 4-6 week intervals throughout the experiment as part of the management recording system for Riverside farm (Parker 1987), and farm staff kept an informal record of labour inputs required for the two shearing options.

Animal Measurements

The liveweight of ewes was recorded each year at pre-lamb shearing (August) and at weaning (November/December). Ewe liveweight, for the respective shearing treatment, was adjusted for greasy fleeceweight at the time of weighing by adding the estimated weight of residual wool (derived from total annual wool production for the year concerned). Liveweights were not adjusted for the products of conception because, based on lambing performance data, these should have been similar for both shearing treatments.

Fleeceweights of all trial ewes were recorded individually over two full years (1989-1990 and 1990-1991). The weights of crutchings (August) and fleece (November/December) were combined to provide the average fleeceweight of ewes shorn conventionally. Wool prices for each group were obtained at the sale following shearing.

The incidence of "dry" ewes (including barren ewes, those which failed to lamb and those which lost all lambs), ewe deaths, ewes cast, ewes assisted at lambing and lamb deaths for each group was recorded over the pre-lambing to docking period. During the 1989 and 1990 lambings a sample of lambs from 80 and 100 ewes respectively in each shearing treatment were weighed and ear tagged. The sex, date of birth and birthrank of lambs were recorded within 24 hours of birth. In the 1991 season, lambs from all of the treatment ewes were recorded. Tagged lambs were weighed again at weaning in each year. The growth rates of lambs were calculated from birth to weaning. Lambing percentages were calculated as lambs docked per ewe present at set stocking.

Statistical Analysis

Because most ewes (other than those which died during the trial) appeared in each year of the study, analyses were conducted within year. Ewe liveweight and fleeceweight data were fitted to a model comprising shearing treatment (pre-lamb vs conventional). The models for lamb birth weight, weaning weight and growth rate included dam's shearing treatment, litter size (single vs multiple) and sex (male vs female). Lamb birth weight was fitted as a covariate in the weaning weight model. Birth weight and weaning weight were adjusted for the interval from shearing to the date of lambing and from the date of birth to weaning respectively.

RESULTS

Ewe Lambing Performance

The lambing performance of the pre-lamb and conventionally shorn ewes over three years is summarised in Table 2.1. Differences in ewe performance with respect to shearing policy were not consistent between years. The percentage of lambs docked per ewe lambing was greater for pre-lamb shorn ewes in 1989 and 1991, while the reverse was true in 1990.

Ewe Liveweight and Fleeceweight

Liveweights of ewes prior to lambing were not affected by shearing treatment in any year while post-weaning liveweights were greater in pre-lamb shorn ewes only in 1989 (Table 2.2).

Annual fleeceweights were significantly ($P<0.001$) greater for pre-lamb shorn ewes than for conventionally shorn ewes in 1990 but not in 1991 (Table 2.2).

Table 2.1 **Number (n) of experimental ewes in each shearing treatment at set stocking for lambing and their lambing performance (%) 1989-1991.**

Parameter	1989		1990		1991	
	Pre[1]	Conv[2]	Pre	Conv	Pre	Conv
Ewes at lambing (n)	250	250	161	153	53	64
Ewe deaths	1.6	1.2	4.3	3.9	1.9	0.0
Ewes cast	3.6	2.0	3.7	3.3	1.9	0.0
Ewes assisted	1.6	1.2	0.6	1.3	1.9	0.0
Dry ewes	9.6	7.6	6.8	3.9	9.4	7.8
Lamb survival to docking	93.2	92.4	85.1	89.5	88.7	87.5
Lambs docked/ewes lambing	126	123	129	140	138	133

1 Pre-lamb shearing treatment.
2 Conventional (post-weaning) shearing treatment.

Table 2.2 **Effect of shearing treatment on ewe liveweight (kg) prior to lambing and at weaning, and on annual fleeceweight (kg) 1989-1991 (Mean±SEM).**

	Pre-lambing LW[1]		Post-weaning LW		Annual fleeceweight	
Year	Pre[2]	Conv[3]	Pre	Conv	Pre	Conv
1989	54.5±0.5	53.0±0.5	60.1±0.5^{b}	57.3±0.4^{a}	-	-
1990	55.7±0.5	55.7±0.5	54.1±0.6	52.8±0.6	4.07±0.05^{b}	3.64±0.06^{a}
1991	56.5±0.7	56.8±0.8	53.6±0.9	53.8±0.9	3.61±0.08	3.75±0.09

1 LW = Liveweight
2 Pre-lamb shearing treatment.
3 Conventional (post-weaning) shearing treatment.
ab Means within rows and main effects having superscripts with letters in common are not significantly different ($P>0.05$).

Lamb Weight and Growth

The birthweights, weaning weights and growth rates of lambs are presented in Table 2.3. None of these variables was affected by shearing treatment.

Table 2.3 **Effect of shearing treatment on lamb birthweight, weaning weight, and lamb growth rates from birth to weaning 1989-1991 (Mean±SEM).**

	Birthweight (kg)		Weaning weight (kg)		Growth rate (g/d)	
Year	Pre[1]	Conv[2]	Pre	Conv	Pre	Conv
1989	4.72±0.09	4.61±0.09	22.8±0.5	22.5±0.6	255±5	254±5
1990	4.38±0.11	4.68±0.11	20.6±0.5	20.2±0.5	223±6	213±6
1991	5.07±0.09	5.00±0.09	21.5±0.7	21.2±0.6	213±5	211±5

1 Pre-lamb shearing treatment.
2 Conventional (post-weaning) shearing treatment.

DISCUSSION

Ewe Lambing Performance

Although the data were not subjected to statistical analysis (because of limited numbers of ewes in each year), shearing treatment did not markedly affect the lambing performance of ewes in any year of the experiment. This is consistent with the results of Sumner & Scott (1990) who found no difference in the percentage of dry ewes, ewe deaths or ewes cast, or in lamb survival, between ewes shorn pre-lamb in July or at weaning (January). Everitt (1961) also reported no significant difference in lambing percentage, incidence of dry ewes or the mortality of ewes (or their lambs) that had been either pre-lamb shorn in June/July or shorn at the conventional time in December.

Ewe Liveweight and Fleeceweight

The small and inconsistent effect of shearing policy on ewe liveweight pre-lambing and at weaning is similar to the findings of Salman & Owen (1986), Black & Chestnutt (1990) and Parker et al. (1991), all of whom found that shearing treatment during pregnancy had no significant influence on ewe liveweight during late pregnancy and lactation.

The annual fleeceweight of ewes pre-lamb shorn in August was greater than that of ewes left unshorn until weaning (November) in 1990 but not in 1991. This inconsistency probably reflected the availability of pasture in each season (Figure 2.1). Pasture cover was greater during spring/summer 1989/1990 than during the corresponding period in 1990/1991. Thus ewes pre-lamb shorn in spring 1989 would have had a greater opportunity to increase voluntary intakes, leading to their greater post-weaning liveweights (than conventionally shorn ewes) in 1989 and greater fleeceweights at the next (1990) shearing. Fleeceweights of ewes pre-lamb shorn in

July and ewes left unshorn until January were similar in the experiment reported by Sumner & Scott (1990), but a greater fleeceweight was recorded for pre-lamb shorn ewes than their December-shorn counterparts by Everitt (1961).

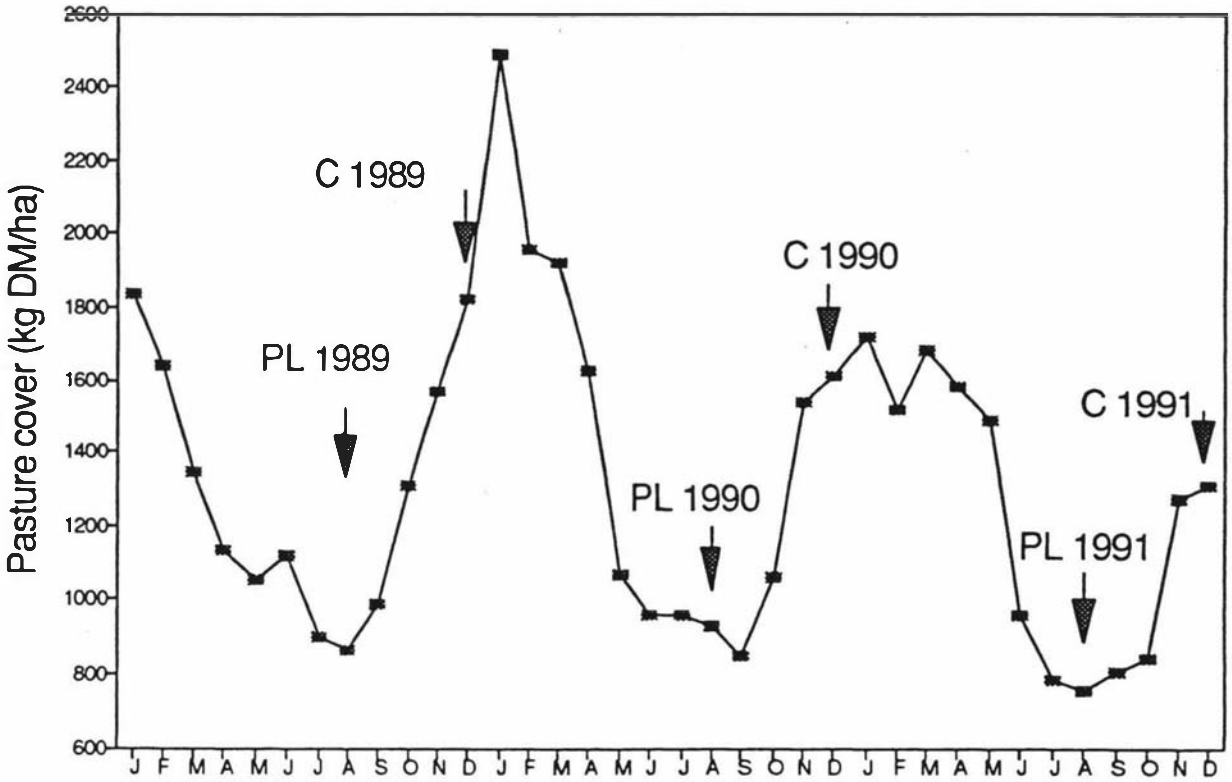

Figure 2.1 **Average monthly pasture cover (kg DM/ha) for Riverside farm from January 1989 to December 1991. PL=date of pre-lamb shearing, C=date of conventional shearing.**

Lamb Production

Lamb birthweight, weaning weight and growth rate were not affected by the dam's shearing treatment. This is consistent with the results of Russel et al. (1985), Orleans-Pobee & Beatson (1989) and Parker et al. (1991), but not with the results of several other studies which reported greater birthweights in lambs of pre-lamb shorn ewes compared with those of unshorn ewes (Maund 1980; Symonds et al. 1986; Vipond et al. 1987; Salman & Owen 1986; Black & Chestnutt 1990). This inconsistency may be related to the fact that shorn animals managed under grazing conditions in a temperate to cold climate (similar to the current study) are less able to increase feed intake in response to shearing than those managed under intensive conditions. As noted in Chapter 1, when food allowance was restricted for both pre-lamb shorn and unshorn housed ewes, the birthweights and growth rates to 14 weeks of age of single or twin lambs were not affected by shearing treatment (Russel et al. 1985). The fact that ewes in the present study were shorn four weeks prior to lambing, rather than the six or more weeks in other studies (Maund 1980; Symonds et al. 1986; Vipond et al. 1987; Salman & Owen 1986; Black & Chestnutt 1990), could also account for the lack of a shearing treatment effect on lamb birthweights.

Financial and Management Considerations

Wool returns for ewes under each shearing regimen are summarised in Table 2.4. Wool handling charges (average $0.16/kg), and the New Zealand Wool Board levy (6% of gross proceeds) were common to shearing policies. On average belly and piece wool amounted to 0.4 kg (0.38-0.41 kg) over the three shearings. In the case of full wool ewes the belly wool was removed at the pre-lamb crutching and only pieces (average 0.19 kg/ewe) were available for sale after the main shear. Shearing charges were $1.50/ewe for pre-lamb and conventionally shorn ewes, but crutching costs were $0.50/ewe/year greater for the latter group.

Fleece prices were consistently higher for the pre-lamb shorn clip and, as a result, the average wool returns for pre-lamb shorn ewes were $2.06/ewe ($2.56 if the difference in shearing costs is included) more than those for conventionally shorn ewes over the 1989-90 and 1990-91 seasons.

In the 1989-90 season wet/dry and dry/dry ewes were sold for $20 and $36/head (nett) for the pre-lamb and main shear policies respectively. The $16 differential was approximately equivalent to the value of the extra wool. In the 1990-91 season pre-lamb shorn ewes were sold for $15/head (nett) and a premium of $3.70/kg was paid for the additional wool on the main shear ewes. Returns for ewe sales from the two shearing policies were therefore similar.

Table 2.4 **Net returns (c/kg greasy) received for wool from pre-lamb shorn (Pre) and conventionally shorn (Conv) ewes 1989-1991.**

	Wool type							
	Fleece		Bellies & Pieces		Crutchings		Income ($/ewe)[1]	
	Pre	Conv	Pre	Conv	Pre	Conv	Pre	Conv
1989-90	370	324[2]	168	274[3]	-	260	13.79	10.30
1990-91	294	263	161	196[3]	-	128	8.90	8.28

1 Adjusted for Wool Board levy (6% gross proceeds) and wool handling charges (15c/kg for fleece wool and 20c/kg oddments).
2 Includes Wool Board post-sale supplement.
3 Pieces only; belly wool removed at crutching.

In a study of the financial effects of shearing on monthly cashflow, Parker & Gray (1989) demonstrated that seasonal overdraft requirements, and hence the annual charge for current account interest, were substantially reduced with a pre-lamb shearing policy compared to those for an annual shearing in December. The higher wool returns from pre-lamb shorn ewes, but similar income for sheep sales (because of small differences in the number and value of ewes and lambs available for sale between shearing policies) meant that a better cashflow pattern was also generated for a pre-lamb shearing policy in the current experiment.

This financial advantage would be reduced if the provision of extra feed for ewes after shearing had an opportunity cost (i.e. if the performance of other classes of stock on the farm was compromised). Farm staff at Riverside found that pre-lamb shearing spread labour requirements and reduced the amount of labour to complete tasks at docking and weaning. However, formal measurements were not obtained to quantify these benefits of pre-lamb shearing.

CONCLUSIONS

Differences in performance of ewes and their lambs due to shearing treatment were small and non-significant under the commercial farming conditions applied to this experiment. However, it was not possible to establish the relative feed efficiency of the two shearing policies because ewe feed intake could not be measured post-shearing. These estimates were obtained in the experiment described in the next Chapter. If annual feed intake was similar for both shearing policies, which the pattern of ewe liveweight between years suggests, farmers could choose between shearing options on the basis of financial, labour input and risk factors. Net financial returns were higher for the pre-lamb shearing policy. Farm staff considered labour requirements were greater for the conventional shearing policy, particularly over the busy period from lambing to weaning. On balance these results suggest that pre-lamb shearing, combined with appropriate management planning to mitigate the risk of adverse weather and feed shortages post-shearing (Parker et al. 1991), would be a worthwhile policy change for New Zealand sheep farmers.

CHAPTER THREE

EFFECTS OF PRE-LAMB SHEARING ON FEED INTAKE AND ASSOCIATED PRODUCTIVITY OF MAY- AND AUGUST - LAMBING EWES

ABSTRACT

The effects of pre-lamb shearing on feed intake and wool/lamb production of May (autumn) - and August (spring) -lambing ewes were studied. In 1990 two groups of mixed age Border Leicester x Romney ewes (60 ewes/lambing season) were selected from a flock at the Massey University Sheep and Beef Cattle Research Unit (Haurongo Block). In each lambing season, the experimental ewes (balanced for pregnancy status and liveweight) were divided at random into two groups. One group was shorn on day 118 of pregnancy (P118) and the second group left unshorn. Measurement of pasture intake was carried out over three periods before lambing and three periods after lambing using intraruminal chromic oxide controlled release capsules. The intake of ewes was not affected by shearing treatment during pregnancy measurement periods except during P141-144 when organic matter intake (OMI) was significantly greater for shorn ewes than for unshorn ewes (1739±58 vs 1526±59 g/d, $P<0.05$). The same trend was found for dry matter intake (DMI). The intake of pre-lamb shorn ewes was non-significantly greater than that of unshorn ewes over the three periods of lactation. Ewe liveweights and condition scores were similar for both shearing treatments during pregnancy and lactation, but back fat depths were significantly ($P<0.05$) lower for the pre-lamb shorn ewes (4.3±0.2 vs 5.1±0.2 mm) at P142. Clean wool growth rate was greater in shorn ewes than in unshorn ewes over the two measurement periods after shearing, but this difference approached significance only during L (lactation day) 13-84 (0.896±0.024 vs 0.801±0.025 $mg/cm^2/d$, $P<0.10$). Over the period P118-L13, pre-lamb shorn May-lambing ewes

produced significantly ($P<0.01$) greater clean wool weights than comparable unshorn ewes (0.927±0.042 vs 0.721±0.048 $mg/cm^2/d$), but this trend was not found for the August-lambing group. Lamb liveweights at birth and over three subsequent measurement times to weaning were not affected by dam's shearing treatment. In general, wool production was greater in May-lambing ewes but lamb production was superior in August-lambing ewes. With few exceptions, effects of lambing policy and shearing treatment were additive.

INTRODUCTION

Shearing is one of the important management practices which can influence sheep production. The time and frequency of shearing may alter the quantity and quality of wool production, reproductive performance, live and carcass weight and feed conversion efficiency in the ewe flock.

The advantages and disadvantages of pre-lamb shearing ewes have been compared with other full wool shearing policies by a number of authors (Coop 1950; Story 1955; Wodzicka-Tomaszewska 1963; Frengley 1964; Henderson 1965; Livingston & Parker 1984). Improved wool colour and fibre strength, often combined with convenience, are the main advantages of pre-lamb shearing (at the end of winter or in early spring), while the risk of cold stress and a deficiency of feed relative to increased demands in shorn ewes are the main disadvantages.

In order to avoid these disadvantages a significant proportion of New Zealand crossbred ewes are shorn post-weaning in early to mid-summer (main shearing) because, during this time, both feed availability and weather are good (Hawker & Littlejohn 1989).

Parker et al. (1991) have shown that pre-lamb shorn ewes consistently had higher intakes during lactation than unshorn ewes. They also demonstrated that growth rate was 5% greater in lambs of pre-lamb shorn ewes. Sumner & Scott (1990) concluded that the returns from once-yearly shearing pre-lambing were greater than the returns from once-yearly shearing post-lambing.

The effects of pre-lamb shearing in autumn- compared with spring- lambing ewes have not been studied. Because autumn-lambing ewes are exposed to better weather conditions and feed supply at lambing, and because they have less variation through the season in fibre diameter (Morris et al. 1994a), it is likely that effects of pre-lamb shearing would differ according to lambing policy.

The objective of this experiment was therefore to study the effects of pre-lamb shearing on feed intake and wool/lamb production of autumn (May)- and spring (August)-lambing ewes.

MATERIALS AND METHODS

Experimental Design and Animals

The design of the trial was a 2x2x2 factorial incorporating the effects of lambing policy (May- vs August-lambing), shearing treatment (pre-lamb shorn vs unshorn) and pregnancy status (single vs multiple).

The trial ewes were mixed age Border Leicester x Romney ewes selected from a flock at Massey University. On 6 December 1990 the ewes were randomly divided into two groups. Because conception rates to the out-of-season (December) mating were expected to be lower than those to the normal (March) mating, 200 ewes were mated in December and 100 in March.

Ewes assigned to the May- and August-lambing groups had oestrus synchronised by insertion of progesterone-impregnated Controlled Internal Drug Releasing Devices (CIDRs, type G, AHI Plastic Moulding Company, Hamilton, New Zealand) for 12 days commencing on 6 December 1990 and 7 March 1991 respectively. Ewes mated in December were also treated with an intramuscular injection of 500 I.U. PMSG (Folligon, Intervet-Australia Pty Ltd) one day before CIDR removal. At CIDR withdrawal, ewes were joined with harnessed entire Romney rams and trial ewes selected from those marked in the first 3 days. Mated ewes were pregnancy diagnosed by real-time ultrasound scanner (Carter 1986) on day 73 of pregnancy. On the basis of these data, 30 single-pregnant and 30 twin-pregnant ewes were randomly selected in each lambing policy group. Half of the single- and twin-bearing ewes in each group were shorn on day 118 of pregnancy (day 0 with respect to shearing). Measurements commenced on day 73 of pregnancy (P73) and ended at weaning on day 84 of lactation (L84).

Pasture Conditions and Grazing Management

Four 1.0 ha paddocks of predominantly ryegrass (L. perenne) and white clover (T. repens) pastures were prepared for grazing studies during the experiment. Sward heights were maintained at 5-6 cm in order to maximise ewe performance (Milne et al. 1981; Penning & Hopper 1985; Hodgson 1990; Parker & McCutcheon 1992; Morris et al. 1994b). Because the experimental area involved both new (1 year old) and old (greater than 3 year) pastures, these pasture types were treated as two blocks to separate possible effects of pasture type and interactions with treatments. In each lambing season, the 60 experimental ewes were randomly divided into two groups (balanced for pregnancy status and liveweight) and one group assigned to each block (2x1 ha paddocks of old or new pasture) on P112. Half of the ewes in each block were then randomly allocated to shearing treatments (balanced for pregnancy status and liveweight). Ewes in each block were rotated between their two paddocks until lambing in order to maintain sward heights at 5-6 cm. On P142 ewes were removed from the treatment paddocks and lambed on a separate paddock where pasture height was 4-5 cm. After lambing (L5), 12 of the 60 ewes were removed so that 24 ewes remained in a block, with each of the two paddocks in a block having 12 ewes, half shorn (6 ewes) and half unshorn (6 ewes) and balanced for rearing rank (single vs twin). Ewes were then set stocked in their respective paddocks until L33. From L33, all ewes of the two blocks were grouped together and rotationally grazed as a single mob until weaning on L84.

Pasture Measurements

Pasture height was measured by taking 50 readings per paddock with both an Ellinbank pasture meter (EPM; Earle & McGowan 1979) and the HFRO sward stick (Barthram 1986) once-weekly from 6 weeks before lambing until the end of the experiment.

Pasture mass was measured three times during the trial (within each policy), on days P112 (pre-shearing), P140 and L21, using a motorised shearing hand-piece. Eight 0.18m^2 quadrat samples per 1ha paddock were clipped to ground level. Each sample was washed to remove soil contamination and oven dried at 80°C to constant weight. After drying, the herbage mass (kg DM/ha) was calculated as described by Frame (1981). The average herbage mass of 8 samples represented the mean herbage mass of each 1ha paddock and the mean of 16 samples (8 per paddock) within each block represented the mean herbage mass of each block.

For determination of pasture composition, 8 pasture samples per 1 ha paddock were collected from the area adjacent to that clipped to ground level in each quadrat. These samples (each approximately 100 g fresh weight) were bulked on a within-paddock basis and, after thorough mixing, randomly divided into 2 sub-samples and then in turn divided into 2 smaller sub-samples. Finally one of these sub-samples was partitioned into grasses, clovers, weeds and dead material. Each component was oven dried at 80°C to constant weight, weighed and pasture composition determined as the dry weight proportions (%) of grasses, clovers, weeds and dead material. Data from each paddock within a block were averaged to give the mean pasture composition of the block.

Animal Measurements

Ewes were weighed on the day mating commenced, at pregnancy diagnosis (P73), 1 hour before shearing and 4 hours after shearing (P118), before lambing (P134), and in early lactation (L13), mid lactation (L33) and late lactation (L84) . All liveweights except that taken immediately post-shearing (P118) were obtained within 1 hour of removal of the ewes from pasture. The difference between the pre- and post-shearing liveweights of ewes shorn at P118 was used to estimate fleece weight and for adjustment of subsequent liveweights of ewes in the shorn group. Electronic scales (Tru-test AG 500) with a 200 Kg suspension cell were used for weighing ewes.

Ewes were condition scored according to the method of Jeffries (1961) on days P73, P142, L13, and L84 . Ultrasonic backfat depths were recorded on the same days by the method of Purchas & Beach (1981).

On day 73 of pregnancy (P73) a 100 cm^2 area of the midside was cleared of wool on each of the 60 selected experimental ewes. Midside sites were clipped and the wool harvested according to Bigham (1974) on P118 (shearing), L33 and L84. The area clipped on each occasion was determined from caliper (Mitutoyo, Tokyo) measurements of the four sides and the diagonal.

Greasy and clean weights of midside samples were measured using the procedures described by Elgabbas (1986). The procedures for washing wool samples and calculating clean wool growth rate are described in Appendix I. Fibre diameter of clipped midside samples was measured by the airflow technique (Ross 1958).

Lambs were weighed, tagged and recorded for sex, date of birth and birthrank within 24 hours of birth. They were again weighed at L13, L33, and L84 (weaning) at the same times and under the same conditions as their dams (i.e. one hour off pasture). Newborn lambs were weighed using a conventional spring balance, but electronic scales were used for weighing older lambs (as for the ewes).

Measurement of Herbage Intake

Herbage intakes of individual ewes were determined by the indirect measurement of intake from in vitro determination of pasture digestibility (D; of dry matter (DM) or organic matter (OM)) and faecal output of grazing animals (FO,g/d DM or OM). Intake (I,g/d DM or OM) was estimated as:

$$I=FO/(1-D)$$ (Geenty and Rattray 1987).

Chromic oxide controlled release capsules (CRC) were used for determination of faecal output (Parker et al. 1989). Ewes were dosed with a single CRC (3.0 cm core of pressed tablet, 65% Cr_2O_3 matrix and 9.00 mm orifice; Captec (NZ) Ltd, Auckland) on each of P105, P134 and L13.

Faecal sampling was carried out per rectum between days 8 and 25 following insertion of each capsule (Parker 1990). There were 6 collection periods, three before lambing and three after lambing (Table 3.1). Samples were bulked (within ewe) across sampling periods except during P119-P130 when individual daily samples were taken. Rectum grab samples were oven dried at 60°C for three days and analyzed for chromium content according the method of Parker et al. (1989).

Four oesophageal-fistulated (OF) wethers were used to collect herbage samples for in vitro digestibility and botanical composition of pastures grazed concurrently by capsule-treated ewes. Extrusa was collected according to the technique of Wait (1972). The collection of extrusa samples corresponded with the times of faecal sampling (Table 3.1).

Table 3.1 Dates of faecal sampling in capsule-treated May- and August-lambing ewes. Oesophageal-fistulated wethers were run with the ewes and extrusa sampled at the same times.

Period	CRC No.	Day of Pregnancy (P) or Lactation (L)	Duration of period: May-lambing	Duration of period: August-lambing
1	1	P113-117	10/4-14/4	10/7-14/7
2*	1	P119-130	16/4-27/4	16/7-27/7
3	2	P141-144	08/5-11/5	08/8-11/8
4	2	L8-11	22/5-25/5	22/8-25/8
5	3	L21-25	05/6-09/6	05/9-09/9
6	3	L29-33	13/6-17/6	13/9-17/9

* Individual faecal samples were taken after shearing (S) on days S1, S2, S3, S5, S8 and S12 (corresponding to P119, P120, P121, P123, P126 and P130).

Collected extrusa was mixed and then subsampled. One subsample was separated for botanical composition (Clark & Hodgson 1986) and the remainder was used for determination of in vitro digestibility by the method of Roughan & Holland (1977). Subsamples of the extrusa prepared for in vitro analysis were bulked within block across the periods P119-130 and L8-11. Total N (Kjeldahl method) and fibre contents (Van Soest & Wine 1967) of herbage were measured on the bulked samples collected during the post-shearing period (P119-130), but only total N content of herbage was measured on the bulked samples collected post-lambing (L8-11).

Statistical Analysis

Data were subjected to analysis of variance for a factorial design to test main effects and their first order interactions. For ewe data, the analysis tested the main effects lambing policy (May vs August), pre-lamb shearing treatment (shorn vs unshorn), litter size (single vs twin), and type of pasture (new vs old). The pre-shearing value of any parameter was used as a covariate for that parameter only for shearing treatment. Litter size was taken as actual number of lambs born (single or twin) for pre-lambing traits and number of lambs docked/weaned for post-lambing traits. The same design was used for lamb data except for the addition of sex of lambs (male vs female). For pasture data the analysis tested effects of lambing policy and pasture type. Non-significant interactions were deleted from the model and the model refitted. Data are expressed as Least Square Means ±Standard Error (SEM) or pooled SE.

All analyses were carried out using the Statistical Analysis System computer package (SAS 1985).

RESULTS

Pasture Conditions

During the period P112-P140 sward height (measured by both EPM and HFRO sward stick) and herbage mass were significantly ($P<0.05$) greater for May-lambing than for August-lambing ewes (Table 3.2). Within each policy, herbage mass was significantly ($P<0.05$) greater for old pasture than for new pasture, particularly in the autumn. Changes in pasture height over time are shown in Appendix II.

The proportion of grass species in cut herbage was significantly greater during spring than during autumn, but pasture type effects within each policy were not significant. The proportion of clover was not significantly different between the two seasons, but within each season old pasture had a significantly lower proportion of clover than new pasture. With the exception of 5% weeds in old pasture during spring, there was no weed in any of the cut herbage samples. The proportion of dead material was greater during the autumn than during the spring, but this differences was significant only for old pasture.

Consistent with the cut herbage, the percentage of grass in extrusa samples collected from oesophageal fistulated (OF) sheep was significantly greater during spring than during autumn. Clover content of extrusa samples was greater during autumn than during spring, but these differences were significant only for new pasture. The percentage of weed in extrusa samples was significantly greater during autumn than during spring. The proportion of dead material in extrusa samples exhibited the same trends as the proportion of dead material in cut herbage, being highest in old pasture during autumn.

Table 3.2 Sward height, herbage mass, botanical composition and in vitro digestibility of herbage grazed by May- and August-lambing ewes at P112-P140 (Mean ±SEM)

	May		August		
	New	Old	New	Old	PSE
Sward Height (cm)					
HFRO sward stick	9.82^{b}	9.92^{b}	6.36^{a}	6.50^{a}	0.75
EPM	10.69^{b}	12.76^{b}	5.78^{a}	7.04^{a}	0.68
Herbage Mass (KgDM/ha)	2959.5^{b}	5720.0^{c}	1759.5^{a}	3461.0^{b}	373.6
Botanical Composition					
Cut Herbage[1]					
Grass	0.435^{a}	0.434^{a}	0.688^{b}	0.683^{b}	0.068
Clover	0.294^{b}	0.063^{a}	0.164^{b}	0.000^{a}	0.035
Weed	0.000^{a}	0.000^{a}	0.000^{a}	0.050^{b}	0.001
Dead Material	0.271^{a}	0.503^{b}	0.149^{a}	0.267^{a}	0.061
Extrusa[2]					
Grass	0.554^{a}	0.673^{a}	0.878^{b}	0.941^{b}	0.050
Clover	0.362^{b}	0.070^{a}	0.116^{a}	0.005^{a}	0.049
Weed	0.079^{b}	0.147^{c}	0.006^{a}	0.040^{a}	0.016
Dead Material	0.005^{a}	0.110^{b}	0.000^{a}	0.015^{a}	0.012
In Vitro Digestibility[1]					
DMD	0.836^{b}	0.754^{a}	0.838^{b}	0.734^{a}	0.023
OMD	0.840^{b}	0.778^{a}	0.837^{b}	0.770^{a}	0.019
DOMD	0.714^{b}	0.626^{a}	0.737^{b}	0.662^{a}	0.015
Ash[1]	0.185^{a}	0.231^{b}	0.146^{a}	0.142^{a}	0.014
N[1]	0.044^{b}	0.029^{a}	0.044^{b}	0.033^{a}	0.003

1 Expressed as a proportion of total dry matter.
2 Expressed as a % 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).

During the period P112-P140, in vitro digestibility values (DMD, OMD and DOMD) measured in extrusa samples were significantly greater in new pasture than in old pasture in both the autumn and spring. Differences between seasons (across pasture types) were not significant. Changes in pasture digestibility over time are shown in Appendix II.

The ash content of herbage was similar within and between seasons except for a greater ash content in the old pasture during autumn.

The nitrogen (N) content of herbage was significantly greater in new pasture than in old pasture in both the autumn and spring. Differences between seasons (across pasture types) were not significant.

The analysis of herbage for fibre composition showed that the average percentage of cellulose, hemicellulose and lignin was respectively 19.0, 19.1 and 3.3% for pasture grazed by May-lambing ewes and 14.6, 20.8 and 1.3% for that grazed by August-lambing ewes.

During the period L0-L33, the height of pasture, measured by HFRO sward stick, was not significantly different between the two seasons (Table 3.3). With the exception of the greater height of old pasture in the autumn, the height of pasture measured by EPM was also not significantly different between the seasons. Herbage mass was similar between the seasons, but old pasture had a significantly ($P<0.05$) greater herbage mass than new pasture within each season.

Table 3.3 **Sward height, herbage mass, botanical composition, and in vitro digestibility of herbage grazed by May- and August-lambing ewes at L0-L33 (Mean ±SEM)**

	May		August		
	New	Old	New	Old	PSE
Sward Height (cm)					
HFRO sward stick	4.75[a]	5.80[a]	5.02[a]	4.95[a]	0.68
EPM	5.20[a]	7.96[b]	4.35[a]	5.46[a]	0.62
Herbage Mass (KgDM/ha)	1222.0[a]	3139.0[b]	1215.0[a]	2423.0[b]	528.4
Botanical Composition					
Cut Herbage[1]					
Grass	0.530[a]	0.475[a]	0.647[b]	0.683[b]	0.096
Clover	0.178[b]	0.000[a]	0.318[b]	0.000[a]	0.051
Weed	0.000[a]	0.000[a]	0.000[a]	0.050[b]	0.002
Dead Material	0.302[b]	0.525[c]	0.035[a]	0.267[b]	0.087
Extrusa[2]					
Grass	0.689[a]	0.650[a]	0.679[a]	0.831[b]	0.050
Clover	0.230[b]	0.046[a]	0.321[b]	0.030[a]	0.049
Weed	0.058[b]	0.132[c]	0.000[a]	0.079[b]	0.016
Dead Material	0.022[a]	0.172[c]	0.000[a]	0.060[b]	0.012
In Vitro Digestibility[1]					
DMD	0.771[b]	0.684[a]	0.838[c]	0.700[a]	0.016
OMD	0.795[c]	0.709[a]	0.834[c]	0.751[b]	0.014
DOMD	0.664[b]	0.613[a]	0.733[c]	0.631[a]	0.011
Ash[1]	0.189[b]	0.158[a]	0.151[a]	0.159[a]	0.016
N[1]	0.039[b]	0.030[a]	0.041[b]	0.033[a]	0.003

1 Expressed as a proportion of total dry matter.
2 Expressed as a % 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).

The proportion of grass species in cut herbage was significantly greater during spring than during autumn, but within each season there were no differences between new and old pastures. The proportion of clover was not different between the two seasons, but within each season old pasture had a significantly lower proportion of clover than new pasture. There were no weeds present in the cut herbage except for a 5% weed content in old pasture during spring. The proportion of dead material was significantly greater during the autumn than during the spring, and within each season old pasture had a greater proportion of dead material than new pasture.

The percentage of grass in extrusa samples was not significantly different between and within seasons, but there was greater proportion of grass present in extrusa from animals grazing the old pasture during the spring.

The proportion of clover in extrusa samples exhibited the same trends as the proportion of clover in the cut herbage. The proportion of weeds in extrusa samples was significantly greater during autumn than during spring and within each season extrusa from animals grazing old pasture had a significantly greater proportion of weeds than that from animals grazing new pasture. Dead material content of extrusa samples was greater during autumn than during spring, but this difference was significant only for old pasture. Consistent with the cut herbage results, the animals grazing old pasture within each season had a significantly greater proportion of dead material in extrusa than the animals grazing new pasture.

The digestibility of extrusa samples (DMD) was greater during spring than during autumn, but this difference was significant only for new pasture. Within each season, new pasture had significantly greater DMD than old pasture. Likewise OMD was greater during spring than during autumn, but this difference was significant only in old pasture. Organic matter digestibility was also greater in new pasture than in old pasture within each season. Corresponding values for the DOMD of extrusa exhibited much the same trends as DMD.

The ash content of extrusa samples was similar within and between seasons, except for the higher ash content found in new pasture during the spring period.

The nitrogen (N) content of herbage was significantly greater in new pasture than in old pasture in both the autumn and spring. Differences between seasons (across pasture types) were not significant.

Animal Performance

Herbage intake

Dry matter (DMI) and organic matter (OMI) intakes of May-lambing ewes were consistently greater than those of August-lambing ewes over the periods P113-117 and P119-130 (Table 3.4). Neither DMI nor OMI were affected by shearing policy or litter size during these periods, but intakes of DM and OM by the ewes grazed on new pasture were significantly greater than those of ewes grazed on old pasture.

The analysis of intake data showed that there were interactions between effects of lambing policy and pasture type. On the new pasture, May-lambing ewes had significantly ($P<0.001$) greater DMI (2736 ± 100 vs 1819 ± 83 g/d) and OMI (2172 ± 84 vs 1546 ± 74 g/d) than August-lambing ewes over the period P113-117. This trend was not found on old pasture, DMI and OMI being respectively 1796 ± 95 vs 1930 ± 84 g/d ($P>0.05$) and 1537 ± 84 vs 1635 ± 74 g/d ($P>0.05$).

Table 3.4 Effect of lambing policy, shearing treatment, litter size, and pasture type on ewe herbage intake (g/d) over three periods during pregnancy (Mean ±SEM).

	Dry matter intake			Organic matter intake		
	P113-117[1]	P119-130[2]	P141-144	P113-117[1]	P119-130[2]	P141-144
Policy						
May	2267±69^{b}	1975±49^{b}	2095±80	1855±60^{b}	1719±39^{b}	1810±63^{b}
August	1875±59^{a}	1809±45^{a}	2055±70	1591±52^{a}	1452±36^{a}	1455±54^{a}
Shearing						
Unshorn	2050±63	1857±46	1947±75^{a}	1684±56	1557±37	1526±59^{a}
Shorn	2091±65	1927±47	2202±74^{b}	1760±56	1614±38	1739±58^{b}
Litter Size						
1	2016±64	1952±47	2080±76	1678±56	1615±37	1626±59
2	2125±64	1833±47	2069±74	1767±56	1557±38	1639±58
Pasture type						
New	2278±65^{b}	2188±46^{b}	2666±75^{b}	1859±56^{b}	1701±37^{b}	1936±58^{b}
Old	1864±63^{a}	1596±47^{a}	1483±75^{a}	1586±56^{a}	1471±38^{a}	1330±59^{a}

1 P113 for May-lambing ewes = 10 April.
P113 for August-lambing ewes = 10 July.

2 P119-130 = mean of six daily individual DMI and OMI.

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

The analysis of DMI and OMI on selected days immediately post-shearing (P119-130) is summarized in Tables 3.5 and 3.6. Differences in DMI between May- and August-lambing ewes were not significant on day one (P119) or day two (P120) after shearing. The DMI of May-lambing ewes were greater (P<0.01) than those of August-lambing ewes on P121, P123 and P126 while the reverse was true on day 12 after shearing (P130).

Dry matter intakes of shorn ewes were consistently greater than those of unshorn ewes on each measurement day after shearing (P119 to P130), but this difference was significant only at P121, three days post-shearing (2052 vs 1820 g/d, P<0.05).

Differences in DMI between single- and twin-bearing ewes were non-significant, while differences between ewes grazed on new and old pasture were significant on all days after shearing.

The analysis of intake data indicated that there were shearing x policy and shearing x pasture type interactions during days one to three post-shearing (P119 to P121). Pre-lamb shorn May-lambing ewes had significantly (P<0.01) greater DMI than unshorn ewes on P119 (1978±93 vs 1591±113 g/d) and P121 (2370±123 vs 1849±124 g/d), but this trend was not found during August (P119; 1561±85 vs 1711±85 g/d, P>0.05 and P121; 1734±107 vs 1791±105 g/d, P>0.05). Dry matter intakes were significantly greater for shorn ewes than for unshorn ewes when they grazed old pasture at P119 (1622±90 vs 1274±97 g/d, P<0.05) and P120 (1731±92 vs 1473±88 g/d, P<0.05), but not when ewes grazed new pasture (P119; 1917±88 vs 2027±99 g/d, P>0.05 and P120; 2175±95 vs 2382±94 g/d, P>0.05).

Table 3.5 Effect of lambing policy, shearing treatment, litter size, and pasture type on ewe herbage DM intake (g/d) at six times after shearing during pregnancy (Mean ±SEM).

	P119[1]	P120	P121	P123	P126	P130
Policy						
May	1784±73	1886±71	2109±87[b]	2099±72[b]	1896±64[b]	1991±85[a]
August	1636±60	1995±60	1762±75[a]	1610±66[a]	1614±57[a]	2275±78[b]
Shearing						
Unshorn	1651±70	1928±65	1820±81[a]	1824±68	1715±60	2159±78
Shorn	1769±63	1953±67	2052±81[b]	1885±70	1795±62	2107±84
Litter Size						
1	1753±67	1960±64	2035±79	1918±68	1796±61	2237±78
2	1667±66	1920±67	1836±83	1790±70	1714±61	2028±85
Pasture type						
New	1972±66[b]	2279±67[b]	2275±84[b]	2142±69[b]	2083±61[b]	2297±80[b]
Old	1448±66[a]	1602±64[a]	1597±79[a]	1566±69[a]	1427±60[a]	1969±82[a]

1 P119 for May-lambing ewes corresponds with S1 = 16 April.
P119 for August-lambing ewes corresponds with S1 = 16 July.

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

Organic matter intake exhibited the same trends as DMI, but effects of shearing policy on OMI were not significant on any of the days post-shearing (Table 3.6). Pre-lamb shorn May-lambing ewes had significantly (P<0.01) greater OMI than unshorn ewes on P119 (1752±82 vs 1387±99 g/d) and P121 (1957±96 vs 1594±92 g/d), but this trend was not found during August (P119; 1210±75 vs 1320±72 g/d, P>0.05 and P121; 1301±81 vs 1439±78 g/d, P>0.05). Organic matter intake was significantly greater for shorn ewes than for unshorn ewes when they grazed old pasture at P119 (1484±79 vs 1128±84 g/d, P<0.01) and P120 (1615±77 vs 1372±74 g/d, P<0.05), but not when ewes grazed new pasture (P119; 1476±77 vs 1579±84 g/d, P>0.05 and P120; 1692±80 vs 1849±79 g/d, P>0.05).

The results of intake measurements over the third period of pregnancy (P141-144) are also given in Table 3.4.

Intakes of DM and OM by May-lambing ewes were greater than those of August-lambing ewes over the period P141-144, but this difference was significant only for OMI (1810 vs 1455g/d, P<0.001). Dry matter and organic matter intake were significantly greater for shorn ewes than for unshorn ewes during P141-144. Neither measure of intake was affected by litter size over this period, but DMI and OMI were significantly (P<0.001) greater in ewes grazed on new vs old pasture.

August-lambing ewes had a greater DMI during P141-144 than May-lambing ewes on new pasture (2960±100 vs 2373±111 g/d, P<0.001), but this trend was reversed when ewes grazed old pasture (1150±97 vs 1817±114 g/d, P<0.001). Despite there being no significant difference in OMI between August- and May-lambing ewes when grazed on new pasture (1860±77 vs 2011±88 g/d, P>0.05), the August-lambing ewes had lower OMI than May-lambing ewes when grazed on old pasture (1050±76 vs 1610±89 g/d, P<0.001). Thus policy x pasture type interactions were significant (P<0.05) for both DMI and OMI.

Table 3.6 **Effect of lambing policy, shearing treatment, litter size, and pasture type on ewe herbage OM intake (g/d) at six times after shearing during pregnancy (Mean ±SEM).**

	P119[1]	P120	P121	P123	P126	P130
Policy						
May	1569±64[b]	1658±59	1775±66[b]	1795±56[b]	1641±54[b]	1764±79
August	1265±52[a]	1605±51	1370±56[a]	1223±51[a]	1392±49[a]	1889±72
Shearing						
Unshorn	1353±61	1610±55	1516±60	1487±52	1481±51	1846±72
Shorn	1481±56	1654±56	1629±63	1532±54	1552±52	1807±78
Litter Size						
1	1442±58	1651±54	2035±79	1540±53	1556±51	1866±73
2	1393±58	1612±56	1836±83	1478±54	1477±51	1787±78
Pasture type						
New	1527±57[b]	1770±56[b]	1690±63[b]	1587±53[b]	1679±51[b]	1846±73
Old	1307±58[a]	1493±53[a]	1455±59[a]	1432±53[a]	1353±51[a]	1807±76

1 P119 for May-lambing ewes corresponds with S1 = 16 April.
P119 for August-lambing ewes corresponds with S1 = 16 July.

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

DMI and OMI of May- and August-lambing ewes were also measured over three periods during lactation (Table 3.7).

The intakes of DM and OM by May-lambing ewes were significantly greater than those of August-lambing ewes over the first period of lactation (L8-11), but this trend was reversed during the second (L21-25) and third (L29-33) periods.

While DMI and OMI of shorn ewes were consistently greater than those of unshorn ewes over the three periods of lactation, these differences were not significant. Similarly, the DMI and OMI of twin-rearing ewes were consistently greater than that of single-rearing ewes over the three periods of lactation, but this difference was significant ($P<0.05$) only during the second period (L21-25).

Herbage intakes of ewes grazed on new pasture were significantly ($P<0.01$) greater than those of ewes grazed on old pasture over all the lactation measurement periods.

Ewe liveweights

Differences in liveweight between May- and August-lambing ewes were not significant except on P118 when liveweights were greater ($P<0.001$) in May-lambing ewes (Table 3.8).

In spite of the similar liveweights at shearing (P118), the shorn ewes were consistently, but not significantly, heavier (2-4 kg) than unshorn ewes during all periods from shearing until weaning.

Table 3.7 Effect of lambing policy, shearing treatment, litter size,and pasture type on ewe herbage intake (g/d) over three periods during lactation (Mean ±SEM).

	Dry matter intake			Organic matter intake		
	L8-11[1]	L21-25	L29-33	L8-11	L21-25	L29-33
Policy						
May	2142±85^{b}	1855±81^{a}	2363±88^{a}	1832±69^{b}	1515±56^{a}	1761±63^{a}
August	1836±80^{a}	2562±81^{b}	3314±87^{b}	1473±65^{a}	1807±56^{b}	2328±63^{b}
Shearing						
Unshorn	1916±84	2105±76	2774±83	1605±68	1593±53	2036±59
Shorn	2063±81	2311±86	2903±93	1700±65	1729±60	2053±67
Litter Size						
1	1922±83	2088±77^{a}	2829±84	1591±67	1584±54^{a}	2078±60
2	2057±83	2329±84^{b}	2848±91	1715±67	1737±59^{b}	2011±66
Pasture type						
New	2285±82^{b}	2825±81^{b}	3619±89^{b}	1809±66^{b}	1956±56^{b}	2415±63^{b}
Old	1693±83^{a}	1591±79^{a}	2058±86^{a}	1496±67^{a}	1365±55^{a}	1675±62^{a}

1 L8 for May-lambing ewes = 22 May.
L8 for August-lambing ewes = 22 August.

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

Twin-bearing ewes were significantly heavier than single-bearing ewes during pregnancy (by 4.6 kg at P118 ($P<0.01$) and 6.0 kg at P134 ($P<0.001$)), but the differences were no longer apparent during lactation.

Ewes grazed on new pasture were significantly heavier than ewes grazed on old pasture at P118 and P134. This liveweight difference persisted during lactation, but was not significant at L13.

Back fat depth and condition score

Back fat depth (BFD) of May- and August- lambing ewes was similar at P142 but the BFD of shorn ewes was significantly lower than that of unshorn ewes (Table 3.9). Single- and twin-bearing ewes had similar BFD while ewes grazed on new pasture had significantly greater BFD than ewes grazed on old pasture.

Differences in condition score (CS) between May- and August-lambing ewes were not significant except on P142 when CS was greater in August-lambing ewes. The CS of ewes during pregnancy and lactation was not affected by shearing treatment, but was consistently greater in single- vs twin-bearing/rearing ewes and in those grazed on new pasture vs those grazed on old pasture.

Table 3.8 Effect of lambing policy, shearing treatment, litter size, and pasture type on ewe liveweight (kg) at five times during pregnancy and lactation (Mean ±SEM).

	P118[1]	P134	L13	L33	L84
Policy					
May	67.1±1.12[b]	69.5±1.07	60.6±1.15	55.0±1.13	53.7±1.12
August	61.5±0.92[a]	68.7±0.97	59.7±1.17	57.4±1.14	55.6±1.56
Shearing					
Unshorn	64.0±0.98	68.2±1.03	58.7±1.08	55.0±1.05	52.9±1.09
Shorn	64.6±0.96	70.0±1.01	61.6±1.22	57.4±1.21	56.4±1.58
Litter Size					
1	62.0±0.99[a]	66.1±1.05[a]	59.5±1.11	56.1±1.10	55.3±0.97
2	66.6±0.94[b]	72.1±0.99[b]	60.7±1.20	56.3±1.1	54.0±1.66
Pasture type					
New	66.4±0.95[b]	72.7±1.00[b]	61.4±1.14	58.3±1.13[b]	57.2±1.36[b]
Old	62.2±0.99[a]	65.6±1.04[a]	58.9±1.17	54.1±1.13[a]	52.1±1.36[a]

1 P118 for May-lambing ewes = 15 April.
P118 for August-lambing ewes = 15 July.

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

Table 3.9 **Effect of lambing policy, shearing treatment, litter size, and pasture type on ewe back fat depth(BFD, mm) at P142 and on condition score (CS, arbitrary units) at three periods during pregnancy and lactation (Mean ±SEM).**

	BFD(P142)[1]	CS(P142)	CS(L33)	CS(L84)
Policy				
May	4.8±0.2	2.6±0.1[a]	1.8±0.1	2.1±0.1
August	4.6±0.2	3.0±0.1[b]	2.0±0.1	2.4±0.1
Shearing				
Unshorn	5.1±0.2[b]	2.8±0.1	1.9±0.1	2.2±0.1
Shorn	4.3±0.2[a]	2.8±0.1	1.9±0.1	2.3±0.1
Litter Size				
1	4.7±0.2	2.9±0.1[b]	2.0±0.1[b]	2.4±0.1[b]
2	4.5±0.2	2.7±0.1[a]	1.7±0.1[a]	2.1±0.1[a]
Pasture type				
New	5.0±0.2[b]	2.9±0.1[b]	2.0±0.1[b]	2.5±0.1[b]
Old	4.4±0.2[a]	2.7±0.1[a]	1.7±0.1[a]	2.1±0.1[a]

1 P142 for May-lambing ewes = 9 May.
P142 for August-lambing ewes = 9 August.

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

Wool growth and fibre diameter

Clean wool growth was significantly greater in May-lambing ewes than in August-lambing ewes over the periods P73-118 and P118-L13 while the reverse was true over the period L13-84 (Table 3.10).

Clean wool growth was greater in shorn ewes than in unshorn ewes over the two measurement periods after shearing, but this difference approached significance only during L13-84 (0.896 vs 0.801 $mg/cm^2/d$, $P<0.10$).

Clean wool growth was significantly greater in single-bearing ewes than in twin-bearing ewes during P73-118 but was not affected by rank during P118-L13 and L13-84. Ewes grazed on new pasture produced more wool than ewes grazed on old pasture over the two periods after shearing, but the difference was significant only during P118-L13.

The analysis of wool growth data indicated that there was an interaction between lambing policy and shearing treatment during the post-shearing (P118-L13) period. Pre-lamb shorn ewes produced significantly ($P<0.01$) greater clean wool weights than unshorn ewes during May (0.927±0.042 vs 0.721±0.048 $mg/cm^2/d$), but this trend was not found during August (0.542±0.041 vs 0.641±0.045 $mg/cm^2/d$, $P>0.05$).

Fibre diameter was significantly greater in May-lambing ewes than in August-lambing ewes at P118 and L13 but there was no effect of policy at L84 (Table 3.11). Fibre diameter was not affected by shearing treatment or litter size, but was greater in ewes grazed on new pasture than in ewes grazed on old pasture at L13 and L84.

Table 3.10 Effect of policy, shearing treatment, litter size and pasture type on ewe midside clean wool growth ($mg/cm^2/d$) over three periods during pregnancy and lactation (Mean ±SEM).

	P73-P118[1]	P118-L13	L13-84
Policy			
May	0.881±0.025^{b}	0.824±0.032^{b}	0.777±0.025^{a}
August	0.481±0.024^{a}	0.591±0.030^{a}	0.920±0.024^{b}
Shearing			
Unshorn	0.676±0.025	0.681±0.033	0.801±0.025
Shorn	0.686±0.024	0.734±0.029	0.896±0.024
Litter Size			
1	0.725±0.025^{b}	0.716±0.032	0.849±0.025
2	0.637±0.023^{a}	0.700±0.031	0.848±0.024
Pasture type			
New	0.672±0.024	0.764±0.030^{b}	0.873±0.024
Old	0.691±0.025	0.652±0.032^{a}	0.824±0.025

1 P73-118 for May-lambing ewes = 1 March- 15 April.
P73-118 for August-lambing ewes = 1 June - 15 July.

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

Table 3.11 Effect of lambing policy, shearing treatment, litter size and pasture type on ewe midside fibre diameter (μm) at three times during pregnancy and lactation (Mean±SEM).

	P118[1]	L13	L84
Policy			
May	40.59±0.32[b]	40.35±0.46[b]	37.97±0.40
August	35.54±0.30[a]	36.60±0.44[a]	38.56±0.43
Shearing			
Unshorn	37.95±0.32	38.38±0.47	37.87±0.42
Shorn	38.18±0.31	38.58±0.42	38.65±0.41
Litter Size			
1	38.31±0.33	38.45±0.46	38.44±0.41
2	37.82±0.30	38.50±0.44	38.07±0.43
Pasture type			
New	37.89±0.30	39.43±0.43[b]	38.86±0.41[b]
Old	38.24±0.32	37.53±0.46[a]	37.66±0.42[a]

1 P118 for May-lambing ewes = 15 April.
P118 for August-lambing ewes = 15 July.

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

Lamb live weight

August-born lambs were significantly ($P<0.001$) heavier than May-born lambs at all measurement dates (Table 3.12). With increasing age the liveweight differences between August- and May- born lambs increased from 0.86 kg at L13 to 2.30 kg at L33 and 5.70 kg at weaning (L84).

Lamb liveweight was not affected by dam's shearing treatment. Single-born lambs were significantly ($P<0.001$) heavier than twin-born lambs at all ages.

Ewe lambs were consistently lighter than ram lambs at birth and over three subsequents times to weaning, but the liveweight difference was significant only at weaning.

The liveweight of lambs was not affected by pasture type at birth and L13, but lambs reared by ewes on new pasture were significantly ($P<0.01$) heavier than lambs reared on old pasture at L33 and L84.

A significant interaction was apparent between shearing treatment and litter size at L33, single-born lambs from unshorn ewes being significantly ($P<0.01$) heavier than single-born lambs from pre-lamb shorn ewes (12.88 ± 0.36 vs 11.71 ± 0.46 kg), whereas twin-born lambs from unshorn ewes had similar liveweights to twin-born lambs from shorn ewes (9.22 ± 0.31 vs 9.60 ± 0.31 kg). A similar trend was found for lamb liveweight at L84.

Table 3.12 Effect of lambing policy, shearing treatment, litter size, sex and pasture type on lamb liveweight (kg) at four times from birth to weaning (Mean ±SEM).

	L1(Birth)[1]	L13	L33	L84
Policy				
May	3.81±0.13^{a}	6.54±0.15^{a}	09.70±0.28^{a}	15.11±0.45^{a}
August	5.14±0.12^{b}	7.40±0.13^{b}	12.00±0.25^{b}	20.81±0.41^{b}
Shearing				
Unshorn	4.52±0.11	7.00±0.13	11.05±0.24	18.37±0.39
Shorn	4.43±0.13	6.94±0.15	10.65±0.28	17.55±0.45
Litter Size				
1	4.89±0.14^{b}	7.91±0.16^{b}	12.30±0.30^{b}	19.82±0.48^{b}
2	4.06±0.10^{a}	6.03±0.12^{a}	09.41±0.22^{a}	16.10±0.37^{a}
Sex				
Female	4.31±0.13	6.79±0.16	10.49±0.29	17.07±0.46^{a}
Male	4.64±0.11	7.14±0.13	11.22±0.24	18.85±0.39^{b}
Pasture type				
New	4.56±0.12	6.93±0.14	11.41±0.25^{b}	18.82±0.41^{b}
Old	4.39±0.12	7.01±0.14	10.29±0.26^{a}	17.10±0.42^{a}

1 Birth (L1) for May-lambing ewes = 14 May.
Birth (L1) for August-lambing ewes = 14 August.

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

DISCUSSION

Pasture Conditions

The objective of this experiment was to determine the effects of pre-lamb shearing on feed intake, liveweight and wool/lamb production of pregnant and lactating May- and August-lambing ewes.

Comparison between seasonal lambing policies is complicated because of the need to maintain similar pasture conditions in each season. In this study, an attempt was made to keep SSH above 5cm and herbage allowance above 6 kg DM/ewe/d to ensure that sward conditions were not limiting animal performance (Rattray & Jagusch 1978; Milne et al. 1981; Rattray et al. 1982a; Penning & Hopper 1985; Hodgson 1990; Parker & McCutcheon 1992).

Herbage mass and SSH were greater in autumn than in spring, but only during the early part of the trial (P112-140). The greater sward height and mass during autumn was associated with a greater content of dead material and lower proportion of grass. Hence the seasonal difference in amount of green pasture available to ewes was less marked than the corresponding difference in total pasture mass. As a result, digestibility of extrusa samples from OF wethers at P112-140 and, by inference, the digestibility of feed consumed by ewes, was not affected by season. At L0-33, digestibility of extrusa was higher in spring than in autumn, but only in new pastures. This may have been a consequence of the greater clover content of new spring pastures. The average sward height was greater than 5 cm during pregnancy and was around 5 cm during the lactation period and thus was generally consistent with the objectives of sward management as explained above. Pasture mass was always more than 1000 kg DM/ha.

The period P112-140 was the only stage of the trial when there were seasonal differences in SSH. Morris et al. (1993b) have shown that ME intake of autumn- and spring- lambing pregnant ewes increases with SSH over the range 3 to 8 cm, as does liveweight gain. However, midside wool growth and lamb birth weight are not influenced by SSH over this range. Thus differences between the seasons in SSH during the period P112-140 in the present trial could have contributed to differences in ewe intake or liveweight gain. Beyond P140, however, the objective of maintaining similar sward conditions between seasons was attained successfully, and any performance differences between ewes in the two lambing policies were unlikely to have been due to differences in sward conditions.

Pasture type

The experimental area involved both new and old pastures, thus these pasture types were treated as two blocks in the analysis. Organic matter digestibility of extrusa from OF sheep grazing new pasture was always at least 6 % more than that of extrusa from OF sheep grazing old pasture during P112-140 and L0-33. The superior digestibility of new pasture reflected its lower dead material and higher clover content. Although herbage mass and (to a lesser extent) height tended to be greater for old pasture, the ewe performance was always better on the new pasture, reflecting the superior nutritional value of that pasture. Furthermore there were some carryover effects of pasture type since, despite being grazed in one mob after L33, the productivity of ewes and lambs from L33-L84 was still greater for those which had previously been grazed on new pasture.

In general, effects of pasture type were additive with those of lambing policy and shearing treatment. Some lambing policy x pasture type interactions were apparent but they were not consistent (DMI being greater in May- than in August-lambing ewes on new pasture, but not on old pasture, at P113-117 while at P141-144 DMI was greater in August-lambing ewes on new pasture). A shearing treatment x pasture type interaction was apparent only at P119-P120 (immediately after shearing), DMI being greater in shorn than in unshorn ewes on old, but not on new, pasture. Given that, with these few exceptions, effects of pasture type were additive with those of the treatments of primary interest, pasture type will not be considered further here.

Lambing Policy

Ewe feed intake, liveweight, back fat depth and condition score

During the late pregnancy period (P113-144), May-lambing ewes consumed 2.0 to 2.3 kg DM/d (1.7 to 1.9 kg OM/d). This compares favourably with intakes of 2.0-2.4 kg DM/d (1.6-2.0 kg OM/d) recorded by Morris et al. (1993b) for June-lambing ewes on SSH of 4.0 to 8.0 cm. During the equivalent stage of pregnancy (P113-144), August-lambing ewes consumed 1.8 to 2.1 kg DM/d (1.5 to 1.6 kg OM/d). This is similar to the intakes of 1.7-2.5 kg DM/d recorded for August-lambing ewes on high daily pasture allowances of ryegrass-white clover pastures (Rattray & Jagusch 1978; Rattray et al. 1982b), the 2-2.3 kg DM/d (1.8-2.1 kg OM/d) intakes reported by Parker et al. (1991) for ewes on a pasture with SSH of 3.0 to 9.5 cm, and the OM intakes of 1.9 kg/d (Geenty & Sykes 1986) reported for ewes on high daily pasture allowances of ryegrass-white clover pastures.

During late pregnancy (particularly P113-117 and P119-130), feed intake of autumn (May)-lambing ewes was greater than that of spring (August)-lambing ewes. Morris et al. (1993b) observed similar feed intakes in winter (June)- and spring (August)- lambing ewes during the last 4 weeks of pregnancy. The higher SSH during P112-140 in autumn swards than in spring swards during the present trial (as discussed earlier), but similar SSH between seasons in the trial of Morris et al. (1993b), most likely explain the differences between these trials.

May-lambing ewes had greater liveweights than August-lambing ewes at P118, but had similar liveweights at P134, and a similar BFD (but lower CS) at P142. Some of the apparently greater liveweight gain of August-lambing ewes over the period P118-134 related to the wetness of wool due to persistent rain at the time of the P134 weighing. Nevertheless, a greater liveweight gain in August-lambing ewes is consistent with results of a three year study by Morris et al. (1993a) who found that June-lambing ewes gained less weight during late pregnancy than August-lambing ewes. The ability of August-lambing ewes to gain more weight than May-lambing ewes in late pregnancy is consistent with their greater lamb birth weights (see later) but apparently not with their lower (this trial) or similar (Morris et al. 1993b) feed intakes during the same periods.

During the lactation period (L8-33), May-lambing ewes consumed 1.9 to 2.4 kg DM/d (1.5 to 1.8 kg OM/d). This is lower than the intakes of 2.1-3.5 kg DM/d (1.8-3.0 kg OM/d) recorded by Morris et al. (1994b) for June-lambing ewes on SSH of 2.6 to 7.8 cm. The lower OMD of autumn swards (particularly old pasture) in the present trial compared with pasture in the trial of Morris et al. (1994b) most likely explains the differences between the trials. During the equivalent stage of lactation (L8-33), August-lambing ewes consumed 1.8 to 3.3 kg DM/d (1.5 to 2.3 kg OM/d). This compares favourably with intakes of 1.7-1.9 kg OM/d recorded by Parker & McCutcheon (1992) for ewes on SSH of 5-8.5 cm at the same stage of lactation.

Similar intakes of 1.7-3.4 kg DM/d (Rattray & Jagusch 1978; Rattray et al. 1982a), 1.8-2.2 kg OM/d (Geenty & Sykes 1986) and 1.9-2.3 kg OM/d (Milne et al. 1981) were recorded in other trials for ewes during the first 6 weeks of lactation on high daily allowances of ryegrass-white clover pastures.

Feed intake also was affected by stage of lactation, reaching a maximum during L29-33 (weeks 4-5 of lactation). The peak intake at this stage of lactation is compatible with peak intakes during weeks 2-5 of lactation reported in other studies (Gibb & Treacher 1978; Gibb et al. 1981; Milne et al. 1981; Gibb & Treacher 1982; Geenty & Sykes 1986; Parker & McCutcheon 1992).

During the lactation period (L8-33), average OMI was lower for May-lambing ewes than for August-lambing ewes (1.7 vs 1.9 kg OM/d). The greater intake of August-lambing ewes reflected the greater OMD of spring swards (as discussed earlier). The shorter photoperiod during winter and longer photoperiod during spring, which corresponded to the lactation periods of May- and August-lambing ewes respectively, may also have affected relative feed intakes between ewes of the two lambing policies (Forbes et al. 1979; Kay 1979, 1985; Peters et al. 1980; Blaxter 1982; Blaxter & Boyne 1982; Young 1987).

The lower intake in May-lambing ewes was associated with greater ewe liveweight losses during the period L13-33 and slightly lower condition score at L13. This seasonal difference in liveweight changes is consistent with the results of a two year study with crossbred ewes in New Zealand (Reid et al. 1988) and a three year study in the USA (Notter & McClaugherty 1991), both trials indicating a greater liveweight loss over lactation in autumn-lambing ewes than in spring-lambing ewes. Weight loss during the period L33-84 was small and not affected by policy.

Wool production

Midside clean wool growth was significantly greater in May-lambing ewes than in August-lambing ewes over the periods P73-118 and P118-L13, while the reverse was true during L13-84. Fibre diameter was greater in May- than in August-lambing ewes at P118 and L13 but was not affected by policy at L84. Reid et al. (1988) observed greater wool production in autumn-lambing than in spring-lambing ewes during all periods of the year except in September and October when spring-lambing ewes had a greater wool growth rate. A greater wool growth rate in spring-lambing ewes compared with winter-lambing ewes during P140-L77 (1.19 vs 0.91 $mg/cm^2/d$) was also observed by Morris et al. (1994a).

Reid & Sumner (1991) reported a heavier annual fleece (by 0.2 kg clean) and coarser fibre (by 1.7 µm) for autumn-lambing ewes than spring-lambing ewes. Similarly Morris et al. (1993a) showed a greater wool production (by 0.4 kg) for autumn-lambing ewes than spring-lambing ewes, despite similar yearly liveweight changes of both groups. Also, in the USA, Notter & McClaugherty (1991) found a greater fleece weight for autumn-lambing ewes (3.41 kg) relative to spring-lambing ewes (3.09 kg). Although the annual fleece weight was not measured in the present trial, previous studies (Reid et al. 1988; Reid & Sumner 1991; Morris et al. 1993a) have shown that autumn-lambing ewes have a greater total annual fleeceweight than spring-lambing ewes.

The greater wool growth in May-lambing ewes during the period P73-L13 reflected their greater feed intake, and possibly their exposure to greater day length and better climatic conditions. The equivalent period for August-lambing ewes was winter (June- August) and it has been shown for long wooled sheep breeds (Romney, Coopworth and Perendale) that both the efficiency of wool growth and its responsiveness to the plane of nutrition are lower during winter (Hawker 1985). The lower wool growth rates observed during winter are known to be partly a response to shorter days (Sumner 1979; Hawker et al. 1984; Geenty et al. 1984). Similarly the greater wool growth in August-lambing ewes during the period L13-L84 reflected their greater feed intakes and exposure to more favourable climatic conditions, because this period coincided with winter (June- August) in May-lambing ewes but spring (September- November) in August-lambing ewes.

August -lambing ewes exhibited a marked variation in wool growth rate during the experimental period (ranging from 0.48 mg/cm^2/d at P73-118 to 0.92 mg/cm^2/d at L13-84) and a decline in wool growth rate during the winter (P73-L13). Conversely the May-lambing ewes did not show as marked a variation wool growth rate during the experiment (range 0.78 to 0.88 mg/cm^2/d). This is consistent with previous reports that autumn-lambing ewes have a more even pattern of wool growth rate (and fibre diameter) than spring -lambing ewes (Reid et al. 1988; Reid & Sumner 1991; Morris et al. 1994b).

Lamb production

August-born lambs were heavier at birth (by 1.33 kg) and at weaning (by 5.70 kg) than May-born lambs. Overall lamb growth rates from birth to weaning (L1-84) were 133±5 and 188±5 g/d for autumn-born lambs and spring-born lambs respectively. These results are consistent with the results of previous studies showing an effect of seasonal lambing policy on lamb birthweights and growth rates to weaning (Quinlivan 1988; Reid et al. 1988; Peterson et al. 1990; Morris et al. 1993 a,b).

The association of ewe milk production and feed intake (Hodge 1964; Rattray & Jagusch 1978; Gibb et al. 1981; McEwan et al. 1985; Geenty & Dyson 1986; Geenty & Sykes 1986) and the dependence of lamb growth rates on the dam's milk production from birth to six weeks of age (Hodge 1964; Williams et al. 1976; Penning & Gibb

1979; Gibb et al. 1981; Geenty & Dyson 1986) suggest that the higher growth rates of August-born lambs during L13-33 reflected their dams greater feed intakes. The higher growth rate for August-born lambs during L33-84 was not only consistent with better pasture quality during spring, but possibly related to better utilization of energy during spring. Even with forages having similar metabolizability, Corbett et al. (1966) and Rattray & Joyce (1974) have shown that the efficiency of utilization of metabolizable energy for growth was higher during spring than during autumn.

Shearing

Ewe feed intake, liveweight, back fat depth and condition score

Neither DMI nor OMI were affected by shearing treatment during P119-130 (immediately post shearing), but shorn ewes had significantly greater DMI and OMI than unshorn ewes during P141-144. An increase in feed intake, particularly three weeks after shearing, is in agreement with most previous studies of shearing effects (Coop & Drew 1963; Wheeler et al. 1963; Wodzicka-Tomaszewska 1963,1964; Webster & Lynch 1966; Elvidge & Coop 1974; Love et al. 1978; Maund 1980; Morgan & Broadbent 1980; Vipond et al. 1987; Salman & Owen 1986; Black & Chestnutt 1990; Parker et al. 1991). Conversely, no change in feed intake following shearing was observed by Symonds et al. (1986), possibly because of different climatic conditions following shearing (Joyce 1968; Elvidge & Coop 1974), feed availability (Coop & Drew 1963) or types of diet (Black & Chestnutt 1990). Minson & Ternouth (1971) showed that feed quality could significantly influence the change in DMI after shearing, with greatest increases in feed intake being produced when the quality was low. A similar result was found in the present study, DMI being greater in shorn than in unshorn ewes on old (poorer quality) pasture at days P119 and P120, but not on new pasture.

The delay in response of feed intake for up to three weeks after shearing in the present study is consistent with the results of several experiments (Wodzicka-Tomaszewska 1963; Hawker et al. 1985; Phillips et al. 1988). Kennedy et al. (1986) suggested that cold exposure has immediate effects on rumen motility and rate of passage and that these digestive tract responses to cold are necessary to then accommodate increased voluntary feed intake. As a result there is a delay between shearing and the response in voluntary feed intake.

The significantly lower BFD of shorn ewes compared with unshorn ewes at P144 (4.3 vs 5.1 mm) is consistent with a greater heat expenditure and consequently greater lipolysis of body fat depots in the shorn group. Symonds et al. (1986, 1989) indicated that metabolic adaptations in shorn ewes, as a result of chronic cold exposure in late pregnancy, stimulate the mobilization and oxidation of maternal fat reserves to support the higher rate of thermoregulatory heat production.

Feed intake, weight change and condition score during lactation were not significantly affected by shearing treatment. Similarly Salman & Owen (1986), Black & Chestnutt (1990) and Parker et al. (1991) indicated that shearing treatment during pregnancy had no significant influence on these parameters during early lactation.

Wool production

Clean wool growth was greater in shorn ewes than in unshorn ewes over the two measurement periods after shearing, but this difference approached significance only during L13-84 (0.896 vs 0.801 $mg/cm^2/d$, $P<0.10$). This trend of wool growth is consistent with the greater intake of shorn ewes than unshorn ewes. Similarly Parker et al. (1991) did not find a significant difference in wool growth rates between pre-lamb shorn and unshorn ewes. A similar fleeceweight between ewes pre-lamb shorn in July and ewes left unshorn until January was recorded by Sumner & Scott (1990).

Over the period P118- L13, pre-lamb shorn ewes produced significantly ($P<0.01$) greater clean wool weights than unshorn ewes during autumn (0.927 vs 0.721 $mg/cm^2/d$), but not during spring (0.542 vs 0.641 $mg/cm^2/d$, $P>0.05$). This may reflect the higher ambient temperatures to which ewes were exposed during autumn than during spring. Graham et al. (1959) indicated that maximum wool growth for the first week after shearing occurred at around 28°C ambient temperature, but wool growth decreased 30% when the temperature fell to 13°C. They concluded that wool growth immediately after shearing is related to ambient temperature. Severe cold stress, by decreasing skin blood flow (Hopkins & Richards 1979) and increasing glucocorticoid secretion (Wallace 1979), can reduce the rate of wool growth. There was also a corresponding interaction in DMI at days P119 and P121, reflecting a greater DMI for pre-lamb shorn ewes than unshorn ewes in autumn, but not in spring. The greater wool growth rates in pre-lamb shorn autumn-lambing ewes during the period P118-L13 reflected their greater feed intake and exposure to more favourable better climatic conditions, because this period coincided with autumn (April- May) in May-lambing ewes but winter (July- August) in August-lambing ewes.

Lamb production

Lamb liveweight at birth and over the three subsequent measurement times, and hence lamb growth rates, were not affected by dam's shearing treatment. This is consistent with the result of the first experiment (Chapter 2) and some other studies (Russel et al. 1985; Orleans-Pobee & Beatson 1989, Parker et. al 1991), but not with the results of several other studies which reported greater birthweights in lambs of pre-lamb shorn ewes compared with those of unshorn ewes (Maund 1980; Symonds et al. 1986; Vipond et al. 1987; Salman & Owen 1986; Black & Chestnutt 1990). As noted earlier, this is likely to be a function of differences between the studies in ability to increase feed intake, in climatic conditions (housed vs outdoors) and in the time of shearing relative to lambing.

CONCLUSIONS

This study was generally consistent with the results of previous studies examining effects of shearing treatment and lambing policy on the productivity of ewes. Thus pre-lamb shearing was associated with increased feed intakes (particularly 2-3 weeks after shearing), a depression of ewe back fat depth (at P142), but little effect on midside wool growth rate or lamb birthweight and subsequent growth. Likewise, lambing policy influenced: feed intake during pregnancy, midside wool growth rate, fibre diameter (in favour of May-lambing ewes); and feed intake during lactation, lamb birthweight and lamb growth (in favour of August-lambing ewes). Some, but not all, of the lambing policy differences could be attributed to differences in herbage allowance which was generally greater for May-lambing ewes during late pregnancy.

The unique feature of this study was, however, the opportunity (by virtue of the factorial design) to examine whether effects of pre-lamb shearing were similar in May- and August-lambing ewes. The general lack of interaction between effects of lambing policy and shearing treatment leads to the conclusion that pre-lamb shearing is likely to have similar effects in both lambing policies. One exception to this was in terms of midside wool growth from shearing (P118) to early lactation (L13). During this period, wool growth rate was significantly increased (29%) by pre-lamb shearing in May-lambing ewes but reduced (by 15%) in shorn August-lambing ewes. It can therefore be concluded that pre-lamb shearing has similar disadvantages (increased feed demand relative to supply, loss of ewe condition) in May- and August-lambing ewes but that it enhances wool growth rate to a greater extent in the former policy relative to latter. Pre-lamb shearing is therefore likely to be a viable option for autumn-lambing policies, especially if some of the disadvantages of this shearing regimen can be overcome by use of the cover comb. That issue is addressed in Chapter 4.

CHAPTER FOUR

EFFECT OF SHEARING METHOD ON EWE AND LAMB PRODUCTIVITY AND THE METABOLIC ADAPTATION OF PREGNANT EWES TO FLEECE REMOVAL

ABSTRACT

The effects of pre-lamb shearing ewes with both cover and standard comb, and of leaving ewes unshorn until, after weaning on their feed intake, productivity, metabolic parameters, and ewe and lamb survival were studied in this experiment. In 1992, 300 Border Leicester x Romney ewes from the Massey University Sheep and Beef Cattle Research Unit were diagnosed for pregnancy and then divided into three groups (n=100/group) balanced for pregnancy status, ewe age and liveweight. Two groups of ewes were shorn by either cover comb or standard comb on day 114 of pregnancy (P114) and one group left unshorn until weaning on day 84 of lactation (L84). Ewes were managed under the same conditions during the pregnancy and lactation periods.

Ewes shorn pre-lamb by cover comb had significantly lower losses (3 vs 14 %, $P<0.05$), organic matter intakes (1566±111 vs 1781±115 g/d, $P<0.10$) and biting rates (93.7±1.8 vs 99.2±1.8 bites/min, $P<0.05$) than ewes shorn by standard comb over the immediate post-shearing period. These parameters did not differ between ewes shorn pre-lamb by cover comb and unshorn ewes except biting rate which was greater in the cover comb-shorn group. Twenty days after shearing (P134), the liveweights of ewes were greater in the unshorn group than in the cover comb-shorn group ($P<0.05$) which was in turn heavier ($P<0.05$) than ewes shorn by standard comb. From shearing to P134, only the standard comb-shorn group had negative liveweight changes. Midside clean wool growth rates were 0.372±0.025, 0.502±0.033 and 0.482±0.037 $mg/cm^2/d$

during the post-shearing period in unshorn, standard and cover comb-shorn ewes respectively (P<0.05). Similarly, the yield and brightness of wool were superior (P<0.05) in pre-lamb shorn groups. Lamb liveweights at birth, docking and weaning, and lamb survival, were similar between shearing policies. Rectal temperature (RT) was significantly (P<0.05) lower in both pre-lamb shorn groups than in the unshorn group on day 3 post-shearing (S3), but by S5 only the ewes shorn by standard comb had lower RT. With a few exceptions, blood metabolite and hormone concentrations exhibited the same trend as RT, indicating that the cover comb-shorn group recovered more quickly than the standard shorn group. These results suggest that the greater amount of residual wool in cover comb- vs standard comb-shorn ewes provides a low cost practical method for reducing the two important disadvantages of pre-lamb shearing in New Zealand, namely increased cold-stress and feed intakes post-shearing.

INTRODUCTION

Pre-lamb shearing of ewes offers a number of advantages over traditional post-weaning shearing policies. These can include increased wool growth rate and annual fleece weight (see, for example, Chapters 2 and 3), improved wool quality (Story 1955, 1959; Story & Ross 1959, 1960; Sumner 1985), reduced overdraft charges for seasonal finance, lower shearing costs through the elimination of pre-lamb crutching, and an improved spread of farm labour requirements (Parker & Gray 1989). Some studies, particularly those conducted under housed systems, have also shown that pre-lamb shearing can increase lamb birthweights and pre-weaning growth rates (Thompson et al. 1982; Symonds et al. 1986, 1988a,b). Such effects were not, however, observed in the studies conducted here (Chapter 2 and 3), possibly because the ability of the pre-lamb shorn ewe to provide nutrients to her foetus/lamb differs depending on the environmental and nutritional conditions to which she is exposed.

These advantages are offset to some extent by the fact that pre-lamb shearing can place ewes under considerable cold-stress (Holmes et al. 1992) leading to increased feed intake (Chapter 3) and the possibility of increased ewe losses (Hutchinson & McRae 1969). The use of a 'cover comb', which leaves a greater depth of residual wool (stubble) after shearing than the standard comb, and hence increases the insulative value of the remaining fleece (Holmes et al. 1992), has the potential to reduce the severity of some of these effects. However, use of the cover comb has not been studied extensively under New Zealand conditions. The objective of this study was therefore to examine the effects, on ewe and lamb productivity, ewe feed intake and metabolic parameters, of cover comb vs standard comb shearing in pre-lamb shorn ewes compared with corresponding parameters in ewes not pre-lamb shorn.

MATERIALS AND METHODS

Experimental Design and Animals

The experimental design was a 3x2x2 factorial, with three shearing treatments (pre-lamb shearing by standard comb or cover comb and unshorn (post-lamb shearing)), two levels of pregnancy/rearing rank (single and multiple-bearing/rearing) and two ewe ages (2-year old and older).

Border Leicester x Romney (BLxR) ewes from the Massey University Sheep and Beef Cattle Research Unit (SBCRU) were used in the experiment. The ewes were shorn after weaning in November 1991 and joined with rams in March 1992. Mated ewes were pregnancy diagnosed by real-time ultrasound scanning (Carter 1986) at day 52 of pregnancy. Ewes were then allocated into three groups (n=100/group) balanced for pregnancy status, ewe age and liveweight, and each group assigned to one of the three shearing treatments which would be applied later. Sub-groups of 30 ewes (balanced for age, liveweight and pregnancy status) within each experimental group of

100 ewes were identified for the measurement of condition score and midside wool growth. The wool from the midside patch of all sub-group ewes was clipped to skin level on day 72 of pregnancy (P72; 5 June 1992). Thirteen days before shearing (P101; 4 July 1992), 20 ewes from within each sub-group were identified for feed intake and blood sampling measurements. Each of these ewes was dosed with a single chromic oxide controlled release capsule (CRC; Captec (NZ) Ltd, Auckland) to facilitate the measurement of herbage intake. At the same time wool from their necks was clipped to simplify the collection of jugular blood samples. Each group of 20 ewes comprised 10 single-rearing and 10 twin-rearing ewes (balanced for liveweight and age).

On day 114 of pregnancy (P114 or shearing day 0 (S0); 17 July 1992) two of the main groups were shorn, one with a cover comb and the other with a standard comb. The third group was left unshorn, but crutched in the normal manner in preparation for lambing. Ewe fleeceweights (and crutchings from unshorn ewes) and liveweights (1 h off pasture pre-shearing and 24 h fasted before weighing post-shearing) were recorded at this time.

Ewe deaths were recorded from shearing (P114) to weaning (L84).

Grazing Conditions and Pasture Measurements

During the experiment the ewes were grazed on a predominantly mixed ryegrass (L. perenne)/white clover (T. repens) pasture at an average stocking rate of 15 ewes/ha pre-lambing and 12 ewes/ha post-lambing. Between 20 and 25 ha of pasture were used for the 300 ewes during the experiment. With the exception of a few short periods during which measurements were made on the sub-groups of ewes, all of the experimental animals were grazed together in one mob before lambing under the normal rotational grazing management for the SBCRU. Ewes were continuously stocked from one week before lambing until day 40 of lactation (L40) when lambs were docked. During this period ewe numbers in each paddock were balanced for shearing treatment. From L40, all ewes were rotationally grazed as a single mob until weaning on L84.

To maximize ewe performance, the aim was to maintain the height of all of pastures for pregnant and lactating ewes at 4 to 4.5 cm (Parker & McCutcheon 1992; Morris et al. 1993b). Paddock stocking rates were adjusted on the basis of pasture height measurements (see below), so that ewes were offered pasture of similar heights in each of the paddocks grazed.

Pasture height was measured by taking 50 readings per paddock with an Ellinbank pasture meter (Earle and McGowan 1979) once-weekly from 7 weeks before lambing until weaning (L84).

Pasture mass was estimated by cutting twenty 0.18 m^2 quadrats to ground level in four paddocks on days P106 (pre-shearing) and L36. The procedure for cutting, washing and calculating pasture mass was described in Chapter 3. Pasture height was calibrated with pasture mass by recording the pasture height within each sample quadrat and deriving the regression equation (y=a +bx) of herbage mass (y) on the EPM herbage height reading (x). The calibration equation was used to obtain weekly estimates of pasture mass in paddocks used in the experiment.

Pasture composition (i.e. the proportion by dry weight of grasses, clover, weeds and dead material) was assessed from a sub-sample of bulked pasture cut adjacent to the quadrats (see procedure in Chapter 3).

Animal Measurements

Herbage intake

Herbage intake of individual ewes was determined by the indirect measurement of herbage digestibility and faecal output of grazing animals using the procedure outlined in Chapter 3. Ewes which had been dosed with CRC were faecal sampled at P107-110 and P123-126, corresponding to S-7 to S-4 (before shearing) and S9 to S12 (post- shearing) respectively. Faecal samples were bulked within ewes over the 4-day sampling periods on an equal weight basis (0.5 g/d dry matter (DM)). The rate of chromium release from the CRC was assumed to be 139 mg/d, which had been measured by Parker (1990) using similar capsules on the same trial area and under similar pasture conditions.

Faecal output (FO; g/d 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).

Four oesophageal-fistulated (OF) wethers were used to collect herbage samples for determining the in vitro digestibility and botanical composition of herbage consumed. The OF sheep were grazed with the capsule-treated ewes during the periods of intake estimation. Collection of extrusa samples corresponded to the times of faecal sampling in the ewes. Extrusa was collected and analysed for digestibility and botanical composition according to the techniques described in Chapter 3.

The biting rate of ewes used for intake measurements was recorded over the period P123-126. The time taken for 20 bites was recorded by a stop-watch for three time periods per ewe (Hodgson 1982). The average biting rate was calculated as bites per minutes.

Liveweight and condition score

The unfasted liveweights of ewes were recorded at pregnancy diagnosis (P72), 3 days before shearing (P110), before lambing (P134), at docking (L40) and at weaning (L84). All liveweights were obtained within 1 hour of removal of the ewes from pasture. The fasted liveweight of ewes (24 hours after removal from grazing) was recorded immediately after shearing on S0. Ewes were condition scored using the 5 point scale of Jeffries (1961) on days P110, P134, L40 and L84.

Wool production

Following the initial midside patch clipping of 90 ewes (30 per shearing group) on P72, the midside sampling sites (100 cm^2) were clipped on P110 (three days before shearing) using the method described by Bigham (1974). A second midside sample was clipped on day 40 of lactation (L40) and wool growth rate determined from the weight of wool clipped from the midside site (mg wool/cm^2/d). The clean wool growth rate was measured only for the period P110-L40, using the procedure described in Chapter 3. Comparisons of wool growth rate (greasy and clean) were made on the basis of wool weight per unit of skin area for the sampling period (Short & Chapman 1965).

The individual fleeceweights of all ewes shorn pre-lamb and the average crutching weights of unshorn ewes were used to adjust subsequent liveweights of all experimental ewes. A sample of fleece wool from a random selection of 16 ewes in each treatment was taken at pre-lamb shearing (P114) and weaning (L84). Based on these samples the yield, fibre diameter (Ross 1958) and colour (Hammersley & Thompson 1974) of the wool were determined.

Blood metabolite and hormone concentrations

Blood samples from each of 20 ewes in the feed intake sub-groups were collected as follows: before shearing on days S-7 and S-4; and after shearing on days S1, S3, S5, S10 and S20. Ewes were handled quietly to minimise non-shearing effects on blood parameters (especially stress).

Blood samples (10 ml) were withdrawn by venipuncture from the external jugular vein using EDTA vacutainers (Nipro Industries, Japan). These were immediately placed in crushed ice, until the blood plasma could be separated by centrifugation at 3000 g for 20 minutes. Plasma samples were stored at -20°C until analysed. Plasma concentrations of glucose, 3-hydroxybutyrate (3OHB), non-esterified fatty acids (NEFA), growth hormone (GH) and insulin were analysed. Plasma metabolite concentrations were measured on a Cobas Fara II autoanalyzer (F. Hoffmann L.A Roche Ltd., Diagnostics Division, CH-4002 Baslel, Switzerland) and plasma hormone concentrations by the radioimmunoassay technique.

The concentration of glucose was determined with an enzymatic colourimetric assay using glucose oxidase (GOD) and 4-aminophenazone (Trinder, P. 1969). The intra- and inter-assay coefficients of variation (CV) were 1.6 and 3.6 % respectively.

The concentration of 3-hydroxybutyrate was determined using the method of Williamson & Mellanby (1974) as modified by Mackenzie et al. (1989). The intra- and inter-assay CV were 1.3 and 7.8 % respectively.

The concentration of non-esterified fatty acids was determined using an enzymatic colourimetric method (Dalton & Kowalski 1967) as modified by Scott (1989). The intra- and inter-assay CV were 2.5 and 9.6 % respectively.

Plasma concentrations of insulin were measured using a standard double-antibody heterologous competitive binding radioimmunoassay based on that described by Hales & Randle (1963) as modified by McCutcheon & Rumbal (1985). Bovine insulin (Sigma, Catalog No I-5500, 23.4 IU/mg, Lot No. 55F-0536, Sigma Chemical Company, St Louis Mo., USA) was used for radioiodination and as standards, and the first antibody was raised in guinea pigs against bovine insulin. The intra- and inter-assay CV were 8.8 and 14.6 % respectively.

Plasma concentrations of growth hormone were also measured using a double-antibody heterologous competitive binding radioimmunoassay based on that described by Hart et al. (1975) as modified by McCutcheon & Rumbal (1985). Bovine growth hormone was used for radioiodination (USDA-bGH-I1, AFP-6500, 3.2 IU/mg, USDA Reproduction Laboratory, Beltsville Md.) and as standards (USDA-bGH-B1, AFP-5200, 1.9 IU/mg, USDA Reproduction Laboratory, Beltsville Md.), and the first antibody was raised in guinea pigs against bovine growth hormone. The intra- and inter-assay CV were 9.1 and 16.9 % respectively.

Rectal temperature

The rectal temperature of ewes was recorded immediately after blood samples had been obtained (except on day S20). Measurements were made by inserting a digital thermometer (Becton Dickinson, Ontario, Canada) to a depth of approximately 5 cm into the rectum for about 2 minutes until a constant recording was achieved.

Lamb performance

Ewes were shepherded once daily during lambing, and lambs were weighed, tagged and recorded for sex, date of birth and birthrank within 24 hours of birth. All lamb deaths were recorded. Lambs were again weighed at L40 (docking) and L84 (lamb weaning) at the same times and under the same conditions as their dams. Lamb losses were also recorded over the periods L1-40 and L1-84.

Residual wool and shearing method

At the shearing of the full wool group, one side of each of 10 ewes was shorn by standard comb and the other side shorn by cover comb. Residual wool was measured by clipping midside wool samples from both the right and left sides of each ewe immediately after shearing to estimate the amount of wool left by the two shearing methods.

Statistical Analysis

Herbage intake, ewe liveweight, condition score, midside wool growth rate, rectal temperature, wool parameters and the blood metabolite and hormone concentrations of ewes were subjected to analysis of variance at each measurement time. Each model included shearing treatment (fitted last), litter size (single vs multiple) and age as main effects, together with their first order interactions. Actual ewe birthrank rather than diagnosed pregnancy status was used to classify ewes into rank groups. The fasted liveweight of ewes, recorded at shearing, was used as a covariate only for shearing treatments. The pre-shearing values of other parameters (where available) were used as covariates for those parameters.

The same model was used for analysis of liveweight of lambs at birth, docking and weaning except for the addition of sex (male vs female) as a main effect and using birthweight as a covariate for adjusting subsequent weights. Days from shearing to lambing and lambing to weaning were fitted in the model of birthweight and weaning weight respectively.

The proportions of ewe and lamb losses were analysed as binomial traits using the SAS (1985) procedure for categorical data modelling (CATMOD).

All interactions between shearing treatment and other main effects were non-significant. They were therefore deleted from statistical models and only means for main effects are presented.

RESULTS

Pasture Conditions

Table 4.1 summarises the characteristics of the pastures grazed by ewes during the pregnancy and lactation periods. The average pasture height measured by the EPM during the period P106-147 was 5.17 cm but during the period L1-84 it was 4.63 cm. Although the pasture height differences were not great between pregnancy and lactation, the pattern of mean weekly pasture height illustrated in Figure 1 shows that over the period L35-56 the height of pasture was lower than that aimed for (see Material and Methods). This was because weather conditions during winter and spring 1992 were colder and wetter than average, resulting in lower than expected pasture production during the early to mid-lactation period.

Table 4.1 **Sward height, herbage mass, botanical composition, and in vitro digestibility of pasture grazed by ewes during pregnancy (P106-147) and lactation (L1-84) (Mean ±SEM).**

	Pregnancy	Lactation
EPM Sward Height (cm)	5.17±0.35	4.63±0.42
Herbage Mass (kgDM/ha)	2199.0±217.1	1925.0±220.5
Botanical Composition		
Cut Herbage[1]		
Grass	0.827±0.045	0.899±0.050
Clover	0.019±0.005	0.050±0.008
Weed	0.000±0.000	0.036±0.016
Dead Material	0.154±0.010	0.015±0.001
Extrusa[2]		
Grass	0.894±0.062	-
Clover	0.070±0.017	-
Weed	0.000±0.000	-
Dead Material	0.036±0.010	-
In Vitro Digestibility[1]		
DMD	0.753±0.021	-
OMD	0.770±0.028	-
DOMD	0.654±0.017	-
Ash	0.170±0.011	-

1 Expressed as a proportion of total dry matter.
2 Expressed as a % occurrence by point analysis (see Material and Methods).

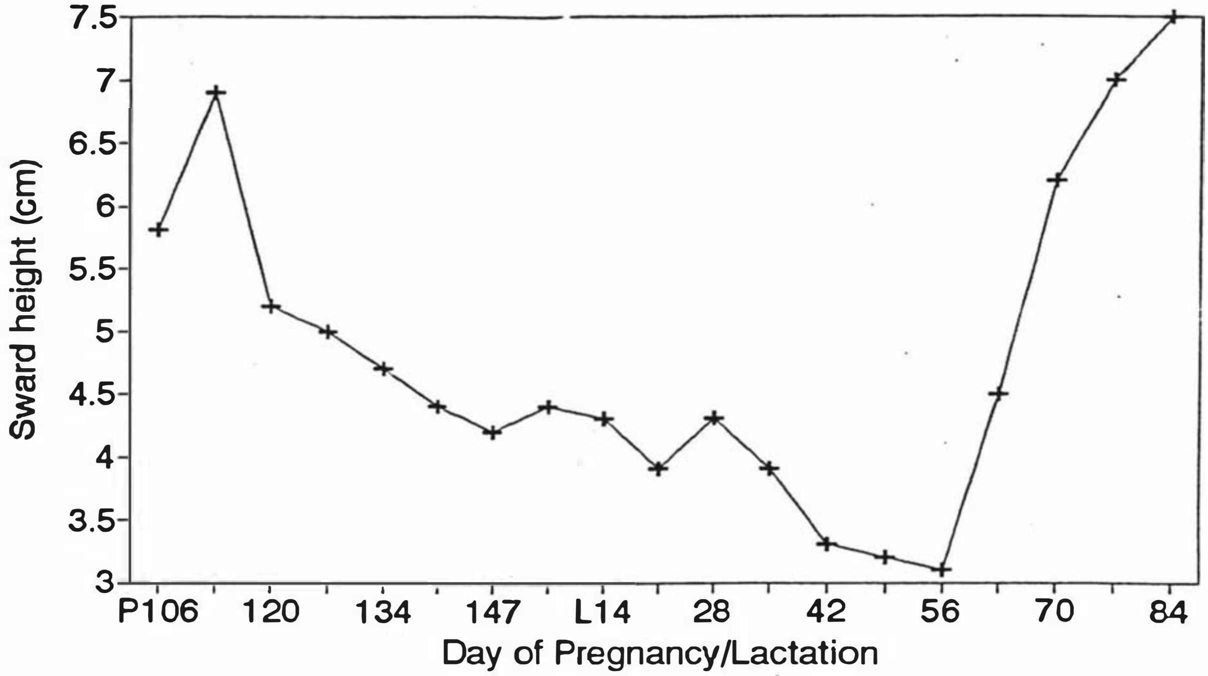

Figure 4.1 Mean Sward height readings, measured by an EPM, over the period d 106-147 of pregnancy (P106-147) and d 1-84 of lactation (L1-84).

Ewe Performance

Ewe losses

The proportions of ewe losses in treatment groups were measured during P115-147 (shearing to lambing). During this period the loss rate of ewes shorn by standard comb was significantly ($P<0.05$) greater than that in either ewes shorn by cover comb or ewes left unshorn until weaning (Table 4.2). Ewe losses during lactation were not affected by treatment (data not shown). The proportion of ewe losses was not affected by litter size or age of ewe.

Table 4.2 Effect of shearing treatment, litter size, and ewe age on ewe losses (%) during pregnancy (post-shearing).

	Ewes present at shearing[1] (P114)	Losses (%) P115-147
Shearing		
Unshorn	96	-3.43±0.58[2](3)[3a]
Standard	91	-1.79±0.30 (14)[b]
Cover	97	-3.44±0.58 (3)[a]
Litter Size		
1	131	-2.87±0.38 (5)
>1	153	-2.46±0.30 (7)
Age		
2	97	-3.14±0.51 (4)
>2	187	-2.44±0.30 (8)
Mean	284	-2.64±0.24 (7)

1 Shearing (S0) = P114 = 17 June 1992.
2 Logit-transformed.
3 Back-transformed (%)
ab Means within main effects having superscripts with letters in common are not significantly different (P>0.05).

Herbage intake and biting rate

The average intakes of dry matter (DMI) and organic matter (OMI) during the pre-shearing (P107-110) and post-shearing (P123-126) periods, and biting rate (BR) of ewes during P123-126, are given in Table 4.3.

The DMI and OMI of ewes shorn by standard comb were greater (P<0.10) than those of unshorn ewes and ewes shorn by cover comb during the period P123-126. In respect of OMI, ewes shorn by standard comb had 265 and 225 g/d greater intakes than unshorn ewes and ewes shorn by cover comb, respectively. The difference in OMI between ewes of the two latter groups was very small. Ewes shorn by standard comb were the only group to exhibit a marked increase in OMI from the pre-shearing period (P107-110) to the post-shearing period (P123-126).

Biting rate of ewes shorn by standard comb was significantly (P<0.05) greater than that of ewes shorn by cover comb, the latter group in turn having a greater biting rate than unshorn ewes.

Dry matter intake, OMI and biting rates of ewes were not affected by litter size. Both DMI and OMI were greater (P<0.10) for older ewes than for young ewes during P107-110. During P123-126 older ewes had significantly (P<0.05) greater DMI, OMI and biting rates than young ewes.

Table 4.3 Effect of shearing treatment, litter size, and age on ewe dry matter intake (DMI), organic matter intake (OMI), and biting rate (BR) during late pregnancy (Mean±SEM).

	DMI (g/d)		OMI (g/d)		BR (b/min)
	P107-110[1]	P123-126[2]	P107-110[1]	P123-126[2]	P123-126
Shearing					
Unshorn	2069±110	1719±126	1585±90	1516±109	85.6±1.7[a]
Standard	2091±111	1997±134	1554±91	1781±115	99.2±1.8[c]
Cover	1950±111	1812±131	1545±91	1566±111	93.7±1.8[b]
Litter Size					
1	2121±100	1829±138	1636±79	1621±121	93.5±1.5
>1	1959±104	1801±126	1490±83	1589±111	91.5±1.5
Age					
2	1912±104	1619±132[a]	1479±82	1435±117[a]	90.5±1.4[a]
>2	2154±083	2041±098[b]	1619±66	1781±087[b]	94.4±1.2[b]

1 P107-110 = 107-110 days of pregnancy which corresponds to 10-13 July 1992 or 7 to 4 days prior to shearing (S-7 to S-4).

2 DMI and OMI values for P123-126 were adjusted for the corresponding data obtained during P107-110 only for shearing policy.

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

Liveweight and condition score

The unfasted liveweights and condition scores of ewes at four times during pregnancy (P110 and P134) and lactation (L40 and L84) and fasted liveweights of ewes at P113 are given in Tables 4.4 and 4.5.

The liveweights and condition scores of ewes were not affected by shearing treatment at any of the measurement times except at P134 when unshorn ewes were heavier than cover comb-shorn ewes ($P<0.05$) which were in turn heavier ($P<0.05$) than standard-shorn ewes.

Multiple-bearing ewes were significantly ($P<0.001$) heavier than single-bearing ewes during pregnancy, but not during lactation. Differences in condition score between multiple-bearing/rearing and single-bearing/rearing ewes were not significant except on P134 when condition scores were greater ($P<0.05$) in single-bearing ewes.

The older ewes were consistently heavier ($P<0.001$) than younger ewes at all measurements times. The condition score difference between old and young ewes was not significant except on L84 when condition score was greater ($P<0.05$) in younger ewes.

Table 4.4 Effect of shearing treatment, litter size, and age on ewe liveweight (kg) at five times during pregnancy (P) and lactation (L) (Mean±SEM).

	P110[1]	P113	P134[2]	L40[2]	L84[2]
Shearing					
Unshorn	59.3±0.2	53.6±0.7	60.3±0.3[c]	46.9±0.9	52.4±0.8
Standard	59.4±0.2	55.5±0.8	58.5±0.3[a]	48.1±0.8	53.1±0.7
Cover	59.4±0.2	53.7±0.7	59.4±0.3[b]	48.0±0.7	53.0±0.6
Litter Size					
1	55.9±0.6[a]	52.3±0.6[a]	55.5±0.7[a]	47.6±0.4	53.0±0.4
>1	60.0±0.6[b]	56.3±0.6[b]	60.4±0.7[b]	47.8±1.1	51.6±1.0
Age					
2	54.2±0.7[a]	50.7±0.7[a]	53.9±0.8[a]	44.0±0.9[a]	49.6±0.9[a]
>2	61.8±0.5[b]	57.8±0.5[b]	61.9±0.5[b]	50.7±0.5[b]	55.5±0.5[b]

1 P110 = 13 July.
2 Fasted liveweight (P113) was used as a covariate only for shearing policy.
abc Means within columns and main effects having superscripts with letters in common are not significantly different (P>0.05).

Table 4.5 Effect of shearing treatment, litter size, and age on ewe condition score (scale 1 to 5) at four times during pregnancy (P) and lactation (L) (Mean±SEM).

	P110[1]	P134[2]	L40	L84
Shearing				
Unshorn	2.06±0.12	1.74±0.11	1.39±0.10	2.55±0.12
Standard	2.39±0.13	1.84±0.14	1.31±0.12	2.45±0.15
Cover	2.09±0.13	1.91±0.11	1.14±0.10	2.30±0.13
Litter Size				
1	2.12±0.11	1.97±0.09[b]	1.36±0.08	2.41±0.09
>1	2.25±0.10	1.69±0.11[a]	1.20±0.16	2.37±0.20
Age				
2	2.19±0.13	1.70±0.12	1.36±0.11	2.62±0.13[b]
>2	2.18±0.09	1.95±0.07	1.20±0.08	2.25±0.09[a]

1 P110 = 13 July.
2 Condition score at P110 was used as a covariate only for shearing policy.
ab Means within columns and main effects having superscripts with letters in common are not significantly different (P>0.05).

Wool growth

Midside greasy wool growth of ewes over the pre-shearing period (P72-110), and both greasy and clean midside wool growth of ewes over the post-shearing period (P110-L40), are given in Table 4.6. During the post-shearing period, both groups of pre-lamb shorn ewes had significantly ($P<0.05$) greater greasy and clean wool growth rates than unshorn ewes.

Neither greasy nor clean wool growth rate was affected by litter size over the measurement periods. Older ewes had significantly ($P<0.05$) greater wool growth rates than younger ewes during the period P72-110 but wool growth rate was not affected by ewe age during the period P110-L40.

Wool characteristics

The yield, fibre diameter and colour of wool clipped at shearing and the residual wool after shearing by standard and cover comb are in Table 4.7.

The wool yield of unshorn ewes was significantly ($P<0.05$) lower than that of both standard comb- and cover comb-shorn ewes. Shearing treatment did not affect the fibre diameter of wool.

Both pre-lamb shorn groups of ewes produced significantly ($P<0.01$) brighter (Y) wool than unshorn ewes, while the yellowness (Y-Z) of wool was not affected by shearing treatment.

The residual greasy and clean wool after shearing was lower ($P<0.01$) in ewes shorn with the standard comb than in ewes shorn with the cover comb.

Table 4.6 Effect of shearing treatment, litter size and age on ewe midside greasy wool growth ($mg/cm^2/d$; P72-P110 and P110-L40) and clean wool growth ($mg/cm^2/d$; P110-L40) during pregnancy and lactation (Mean±SEM).

	Greasy wool P72-P110[1]	Greasy wool P110-L40[2]	Clean wool P110-L40[2]
Shearing			
Unshorn	0.385±0.024	0.514±0.035^{a}	0.372±0.025^{a}
Standard	0.452±0.027	0.664±0.047^{b}	0.502±0.033^{b}
Cover	0.438±0.025	0.637±0.037^{b}	0.482±0.037^{b}
Litter Size			
1	0.447±0.022	0.598±0.031	0.455±0.025
>1	0.402±0.021	0.607±0.030	0.441±0.024
Age			
2	0.371±0.026^{a}	0.609±0.038	0.468±0.030
>2	0.478±0.017^{b}	0.596±0.025	0.429±0.020

1 P72-110 = 5 June - 13 July.

2 Wool growth pre-shearing period (P72-110) was used as a covariate only for shearing policy.

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

Table 4.7 Effect of shearing treatment on ewe wool yield, fibre diameter (FD) and colour, and weight of residual wool after shearing (greasy (GW) and clean (CW)),(Mean±SEM).

	Unshorn	Standard	Cover
Yield (%)	78.6 ± 1.1^{a}	81.9 ± 1.4^{b}	82.9 ± 1.5^{b}
FD (μm)	39.5±0.5	40.7±0.7	40.9±0.7
Colour			
(Y)[1]	60.2 ± 0.4^{a}	63.5 ± 0.5^{b}	62.4 ± 0.6^{b}
(Y-Z)[2]	3.4±0.3	3.4±0.3	4.2±0.4
Residual wool			
GW (mg/cm^2)	-	8.54 ± 0.95^{a}	14.71 ± 1.15^{b}
CW (mg/cm^2)	-	6.36 ± 0.80^{a}	11.52 ± 1.01^{b}

1 Brightness.
2 Yellowness.
ab Means within rows having superscripts with letters in common are not significantly different (P>0.05).

Rectal temperature

The rectal temperature of ewes shorn pre-lamb with a standard comb was significantly ($P<0.05$) lower than that of unshorn ewes on days S3 and S5 (Table 4.8). Ewes shorn with a cover comb tended to be intermediate between these groups.

Table 4.8 Effect of shearing treatment, litter size, and age on ewe rectal temperature (°C) pre-shearing and on days 1, 3, 5 and 10 post-shearing (Mean±SEM).

	S-7 & -4 (Average)	S1[1]	S3	S5	S10
Shearing[2]					
Unshorn	39.5±0.06	39.4±0.09	39.3±0.08[b]	39.4±0.06[b]	39.4±0.06
Standard	39.5±0.06	39.2±0.09	38.9±0.08[a]	39.2±0.06[a]	39.4±0.06
Cover	39.5±0.06	39.4±0.09	39.0±0.08[a]	39.4±0.06[b]	39.3±0.06
Litter Size					
1	39.4±0.05[a]	39.3±0.08	38.9±0.07[a]	39.3±0.05	39.4±0.06
>1	39.6±0.05[b]	39.4±0.07	39.2±0.06[b]	39.4±0.06	39.3±0.06
Age					
2	39.5±0.06	39.4±0.09	39.1±0.08	39.4±0.06	39.4±0.07
>2	39.4±0.04	39.3±0.06	39.0±0.05	39.3±0.05	39.3±0.05

1 S1 = P115 = 18 July 1992.

2 Average rectal temperature on S-7 and S-4 was used as covariate only for shearing policy.

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

Plasma metabolite concentrations

Plasma concentrations of glucose, 3-hydroxybutyrate (3OHB) and non-esterified fatty acids (NEFA), measured twice before shearing (S-7 and S-4) and five times after shearing (S1, S3, S5, S10 and S20), are shown in Tables 4.9, 4.10 and 4.11.

The plasma glucose concentration of ewes shorn pre-lamb by standard comb was significantly ($P<0.01$) greater than that of unshorn ewes only on days S3 and S20 (Table 4.9). The same trend was found between ewes shorn by cover comb and unshorn ewes, but the differences was significant ($P<0.01$) only on day S3. There were no significant differences between the two pre-lamb shorn groups.

The glucose concentration of ewes was not significantly affected by litter size except on day S10 (P124) when the plasma concentration of this metabolite was lower ($P<0.05$) in multiple-bearing ewes than in single-bearing ewes.

Plasma 3-hydroxybutyrate concentration of ewes shorn by standard comb was significantly ($P<0.001$ on day S3 and $P<0.05$ on day S5) greater than that of unshorn ewes (Table 4.10). The same trend was found between ewes shorn by cover comb and unshorn ewes, but the difference was significant at $P<0.05$. There were no significant differences in 3OHB concentration between the pre-lamb shorn groups. The plasma 3OHB concentration of multiple-bearing ewes was significantly ($P<0.001$) greater than that of single-bearing ewes on all measurement days except day S5.

Non-esterified fatty acid concentrations were not affected by shearing treatment except on day S3 when both pre-lamb shorn groups had greater ($P<0.001$) plasma concentrations of NEFA than unshorn ewes (Table 4.11). Plasma NEFA concentrations of multiple-bearing ewes were significantly ($P<0.01$) greater than those of single-bearing ewes on all days except S5.

There was no effect of ewe age on plasma metabolite concentrations.

Table 4.9 Effect of shearing treatment, litter size, and age on ewe plasma glucose concentration (mmol/l) pre-shearing and on days 1, 3, 5, 10 and 20 post-shearing (Mean±SEM).

	S-7 & -4 (Average)	S1[1]	S3	S5	S10	S20
Shearing[2]						
Unshorn	2.93±0.06	3.09±0.08	2.94±0.08[a]	3.07±0.11	2.94±0.06	2.41±0.09[a]
Standard	3.01±0.06	3.22±0.09	3.38±0.08[b]	2.91±0.12	2.96±0.07	2.89±0.11[b]
Cover	2.89±0.06	3.13±0.09	3.35±0.08[b]	3.02±0.10	2.95±0.06	2.63±0.09[ab]
Litter Size						
1	3.02±0.05	3.23±0.07	3.32±0.08	3.12±0.10	3.07±0.06[b]	2.77±0.08
>1	2.87±0.05	3.06±0.07	3.16±0.07	2.95±0.10	2.86±0.06[a]	2.55±0.09
Age						
2	2.98±0.06	3.23±0.08	3.21±0.09	3.11±0.12	2.99±0.07	2.70±0.10
>2	2.91±0.04	3.06±0.06	3.26±0.06	2.96±0.08	2.94±0.05	2.62±0.07

1 S1 = P115 = 18 July 1992.

2 Average glucose concentration S-7 and S-4 was used as a covariate only for shearing policy.

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

Table 4.10 Effect of shearing treatment, litter size, and age on ewe plasma 3-hydroxy-butyrate (3OHB) concentration (mmol/l) pre-shearing and on days 1, 3, 5, 10 and 20 post-shearing(Mean ±SEM).

	S-7 & -4 (Average)	S1[1]	S3	S5	S10	S20
Shearing[2]						
Unshorn	1.11±0.05	1.72±0.15	1.25±0.14[a]	1.97±0.28[a]	1.43±0.09	2.11±0.18
Standard	1.13±0.05	1.87±0.15	2.05±0.14[b]	3.01±0.31[b]	1.39±0.10	2.45±0.20
Cover	1.08±0.05	1.81±0.15	1.83±0.13[b]	2.93±0.27[b]	1.47±0.09	2.48±0.18
Litter Size						
1	0.99±0.05[a]	1.33±0.13[a]	1.35±0.13[a]	2.40±0.29	1.16±0.09[a]	1.78±0.20[a]
>1	1.23±0.04[b]	2.27±0.13[b]	2.08±0.13[b]	2.62±0.23	1.72±0.10[b]	2.95±0.22[b]
Age						
2	1.12±0.05	1.98±0.15	1.84±0.15	2.72±0.36	1.45±0.12	2.38±0.24
>2	1.09±0.04	1.62±0.10	1.56±0.10	2.62±0.23	1.43±0.08	2.35±0.16

1 S1 = P115 = 18 July 1992.
2 Average 3OHB concentration S-7 and S-4 was used as a covariate only for shearing policy.
ab Means within columns and main effects having superscripts with letters in common are not significantly different (P>0.05).

Table 4.11 Effect of shearing treatment, litter size, and age on ewe plasma non-esterified fatty acid (NEFA) concentration (meq/l) pre-shearing and on days 1, 3, 5, 10 and 20 post-shearing (Mean±SEM).

	S-7 & -4 (Average)	S1[1]	S3	S5	S10	S20
Shearing[2]						
Unshorn	0.30±0.03	0.31±0.03	0.20±0.03[a]	0.39±0.04	0.22±0.03	0.87±0.06
Standard	0.36±0.03	0.39±0.03	0.37±0.03[b]	0.40±0.04	0.27±0.03	1.01±0.07
Cover	0.29±0.04	0.32±0.03	0.36±0.03[b]	0.46±0.04	0.26±0.03	0.97±0.06
Litter Size						
1	0.28±0.03[a]	0.22±0.03[a]	0.24±0.02[a]	0.38±0.03	0.19±0.03[a]	0.87±0.05[a]
>1	0.38±0.02[b]	0.47±0.03[b]	0.38±0.02[b]	0.45±0.04	0.31±0.03[b]	1.05±0.06[b]
Age						
2	0.36±0.03	0.38±0.04	0.33±0.03	0.42±0.04	0.25±0.03	0.93±0.06
>2	0.31±0.02	0.31±0.02	0.30±0.02	0.41±0.03	0.25±0.02	0.99±0.04

1 S1 = P115 = 18 July 1992.
2 Average NEFA concentration S-7 and S-4 was used as a covariate only for shearing policy.
ab Means within columns and main effects having superscripts with letters in common are not significantly different (P>0.05).

Plasma hormone concentrations

Differences in plasma growth hormone concentrations between shearing treatments were non-significant on all measurement days except on day S5 when concentrations of this hormone were significantly greater in ewes shorn by standard comb than in either those shorn by cover comb or unshorn ewes (Table 4.12). Younger ewes had significantly ($P<0.001$) greater growth hormone concentrations than older ewes on all except day S5.

Plasma insulin concentrations tended to be higher in pre-lamb shorn ewes than in unshorn ewes but this was significant only on S3 (Table 4.13). Insulin concentration was not significantly affected by litter size or age.

Table 4.12 Effect of shearing treatment, litter size, and age on ewe plasma growth hormone (GH) concentration (ng/ml) pre-shearing and on days 1, 3, 5, 10 and 20 post-shearing (Mean±SEM).

	S-7 & -4 (Average)	S1[1]	S3	S5	S10	S20
Shearing[2]						
Unshorn	13.2±2.3	14.0±2.5	17.0±3.0	08.8±3.2[a]	20.2±3.1	12.7±2.2
Standard	15.0±2.3	14.8±2.5	18.0±3.1	23.0±3.4[b]	19.2±3.5	14.8±2.6
Cover	15.5±2.2	13.9±2.5	14.0±3.0	13.5±3.1[a]	14.3±3.0	11.7±2.1
Litter Size						
1	12.3±1.9	15.5±2.5	17.7±3.1	17.8±3.2	16.6±3.0	13.5±2.2
>1	16.8±1.8	16.2±2.4	19.3±3.0	17.7±3.7	23.1±3.3	15.8±2.4
Age						
2	20.5±2.1[b]	22.0±2.8[b]	26.8±3.5[b]	21.8±4.1	30.0±3.6[b]	19.8±2.6[b]
>2	08.6±1.5[a]	09.6±1.9[a]	10.2±2.4[a]	13.7±2.6	09.7±2.4[a]	09.5±1.8[a]

1 S1 = P115 = 18 July 1992.

2 Average GH concentration S-7 and S-4 was used as a covariate only for shearing policy.

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

Table 4.13 Effect of shearing treatment, litter size, and age on ewe plasma insulin concentration (pg/ml) pre-shearing and on days 1, 3, 5, 10 and 20 post-shearing (Mean±SEM).

	S-7 & -4 (Average)	S1[1]	S3	S5	S10	S20
Shearing[2]						
Unshorn	176.8±24.5	208.4±34.2	190.3±30.7[a]	143.5±21.2	132.1±18.6	48.7±15.2
Standard	211.8±25.4	233.6±31.5	280.4±28.8[b]	152.9±21.6	139.1±21.9	50.2±17.9
Cover	220.5±20.8	208.0±29.1	209.0±28.0[ab]	149.2±20.6	131.8±17.6	81.5±14.4
Litter Size						
1	181.6±18.3	217.7±25.5	234.5±23.8	159.6±16.2	151.1±15.1	66.4±12.4
>1	224.5±20.5	215.6±26.2	218.7±24.0	137.5±18.8	117.5±16.8	53.8±13.8
Age						
2	197.9±23.8	183.9±31.2	219.5±28.1	146.4±21.0	131.5±18.2	56.6±14.9
>2	208.2±13.6	249.4±19.0	233.7±18.3	150.7±12.4	137.1±12.4	63.6±10.1

1 S1 = P115 = 18 July 1992.

2 Average insulin concentration S-7 and S-4 was used as a covariate only for shearing policy.

ab Mean within columns and main effects having superscripts with letters in common are not significantly different (P>0.05).

Lamb losses

The proportions of lamb losses at birth (L1) and from birth to weaning (L1-84) were not affected by shearing treatment and the majority of lamb losses occurred at birth (Table 4.14).

Multiple-rearing ewes had greater lamb losses than single-rearing ewes and this difference was significant ($P<0.05$) over L1-84. Lamb losses were not affected by ewe age or lamb sex.

Lamb liveweight at birth, docking and weaning

The liveweight of lambs at birth (L1), docking (L40) and weaning (L84) was not affected by shearing treatment (Table 4.15).

Single-born lambs were significantly heavier than multiple-born lambs at all measurement days except at L40 when the difference was not significant.

Lambs born to older ewes were consistently heavier than lambs born to younger ewes, but the liveweight difference was significant ($P<0.001$) only at birth. Female lambs were lighter at birth ($P<0.001$) and at weaning ($P<0.05$) than male lambs.

Table 4.14 Effect of shearing treatment, litter size, dam age and sex on the proportion of lamb losses at birth and from birth to weaning.

	Lambs born	L1 (birth)[1]	L1-84
		Proportion (%)	Proportion (%)
Shearing			
Unshorn	140	-1.26±0.20[2](22)[3]	-0.98±0.21 (27)
Standard	112	-1.35±0.23 (21)	-1.07±0.24 (26)
Cover	135	-0.97±0.19 (27)	-0.71±0.20 (33)
Litter Size			
1	110	-1.44±0.24 (19)	-1.27±0.24 (21)[a]
>1	277	-1.08±0.14 (25)	-0.74±0.15 (32)[b]
Age			
2	122	-1.08±0.21 (25)	-0.79±0.22 (31)
>2	265	-1.23±0.15 (23)	-0.96±0.15 (28)
Sex			
Female	190	-1.32±0.18 (21)	-1.01±0.18 (27)
Male	197	-1.05±0.16 (25)	-0.81±0.17 (31)
Mean	387	-1.18±0.12 (24)	-0.91±0.12 (29)

1 Birth (L1) = 21 August 1992 (mean date) = S34.
2 Logit-transformed.
3 Back-transformed (%).
ab Means within columns and main effects having superscripts with letters in common are not significantly different (P>0.05).

Table 4.15 Effect of shearing treatment, litter size, age and sex on lamb liveweight (kg) at birth (L1), docking (L40) and weaning (L84) (Mean±SEM)).

	L1[1]	L40[2]	L84[2]
Shearing			
Unshorn	4.29±0.07	10.38±0.29	17.90±0.46
Standard	4.41±0.07	10.26±0.29	18.06±0.46
Cover	4.35±0.07	09.67±0.28	17.44±0.45
Litter Size			
1	4.69±0.07[b]	10.36±0.20	18.70±0.30[b]
>1	4.01±0.05[a]	09.74±0.38	16.86±0.60[a]
Age			
2	4.15±0.06[a]	09.78±0.39	17.53±0.61
>2	4.54±0.05[b]	10.32±0.19	18.02±0.29
Sex			
Female	4.20±0.06[a]	09.84±0.28	17.22±0.42[a]
Male	4.50±0.05[b]	10.26±0.28	18.33±0.40[b]

1 Birth (L1) = 21 August 1992.
2 Birthweight (L1) was used as covariate only for shearing policy.
ab Means within columns and main effects having superscripts with letters in common are not significantly different (P>0.05).

DISCUSSION

Ewe Losses

The proportion of ewe losses between shearing and lambing (P115-147) was 3, 14 and 3 %, respectively for ewes shorn pre-lamb by either cover comb or standard comb, and ewes left unshorn until after-weaning. The significantly greater losses in the standard comb-shorn ewes contrast with the results reported in Chapter 2, and by Everitt (1961) and Sumner & Scott (1990), where no significant difference between pre-lamb shorn and unshorn ewes was observed. Higher ewe losses in this experiment reflected several days of adverse weather conditions (cold, windy and wet) that commenced on the fourth day after shearing (S4). Hutchinson & McRae (1969) also reported high losses, of 21 to 24 %, for adult Merino wethers following standard shearing when adverse climatic conditions were encountered during a 12-day period after shearing.

The lower ewe losses in the cover comb group than in the standard shorn group reflect the 70% greater amount of wool left by the cover comb (Table 4.7) which increases insulation against cold conditions (Holmes et al. 1992). The majority of ewe losses occurred within two weeks of shearing and the present data support the view that, at least under the conditions encountered here, cover comb shearing can reduce loss rates compared to those of unshorn ewes. The lower losses subsequently, and lack of difference between treatment groups, reflect the fact that wool in the standard shorn ewes had regrown sufficiently to counter the effects of cold stress, and the generally more favourable weather conditions experienced over this time. The consistently greater oxygen consumption of standard- versus cover comb-shorn hoggets during the 12 days following shearing, but not later (Holmes et al. 1992), supports this explanation.

Ewes shorn with a snow-comb exhibited greater rectal and skin temperatures, and lower heart rates, than ewes shorn by standard comb when both groups were exposed to cold and windy conditions for 18-20 hours after shearing (Hutchinson et al. 1960). The greater resistance of the ewes shorn with a snow-comb is consistent with the improved survival of cover-comb shorn ewes in the present experiment, since both alternative types of comb leave a greater depth of stubble than the standard comb.

Ewe Feed Intake, Liveweight and Condition Score

Organic matter intake during the week prior to shearing (P107-110) was 1540 to 1590 g/d. During the post-shearing period (P123-126) OMI was significantly greater in standard comb-shorn ewes (1781 g/d) than in cover comb-shorn or unshorn (1516 g/d) ewes. These values compare favourably with the OMI of 1614 and 1557 g/d, and 1739 and 1526 g/d, reported in Chapter 3 for ewes shorn by standard comb or unshorn over the periods P119-130 and P141-144, respectively, on the same pasture area. The intake of ewes shorn by cover comb was intermediate (1566 g/d OMI) but closer to that of the unshorn group.

The 17% increase in feed intake by the standard comb-shorn ewes relative to the unshorn ewes is similar to the average increase of 15% and 16% in shorn ewes reported by Hudson & Bottomley (1978) and Parker et al. (1991) respectively. The higher intake of both shorn (2078 g/d) and unshorn (1922 g/d) ewes during P108-111 in the experiment of Parker et al. (1991), compared with ewes in this experiment, reflected the higher pasture allowance offered to the ewes, the greater OMD and lower dead material content of pasture in that experiment (80.5-84.9% OMD and 5.0-10.0 % dead material) compared with the present experiment (77.0% OMD and 15.4 % dead material). The post-shearing intake responses in the present experiment are also in agreement with several other studies conducted under both housed and grazing conditions (Coop & Drew 1963; Wheeler et al. 1963; Wodzicka 1963, 1964; Webster & Lynch 1966; Elvidge & Coop 1974; Love et al. 1978; Maund 1980; Morgan 1980; Vipond et al. 1987; Salman & Owen 1986; Black & Chestnutt 1990). Variation in the intake response between experiments reflects differences in climatic conditions (Joyce 1968; Elvidge & Coop 1974), feed availability (Coop & Drew 1963), types of diet (Black & Chestnutt 1990), feed quality (Minson & Ternouth 1971) and physiological state of ewes (Hudson & Bottomley 1978) following shearing. Also, although intake was not measured beyond 12 days after shearing in the present experiment, a response in intake to shearing may be delayed for up to three weeks after shearing (see Chapter 3).

Biting rate was consistent with the level of herbage intake, being 86, 99 and 94 b/min for unshorn ewes and ewes shorn by standard and cover cover comb, respectively, during the post-shearing period. Biting rates of 81-82 b/min were measured by Morris et al. (1993b) in unshorn pregnant ewes grazing pastures in the height range of 2-8 cm.

Ewes shorn by standard comb were lighter than the two other groups at P134 reflecting their greater weight loss from shearing to 2 weeks before lambing (P110 to P134). This trend in liveweight change is consistent with the lower back fat depth measured in ewes which had been shorn in Experiment 2 (see Chapter 3). The failure to detect a difference in condition score between shearing treatments is probably due to the imprecision of subjective assessment techniques rather than to the lack of a shearing effect.

The lack of significant interaction between shearing and litter size is consistent with the results recorded in Chapter 3. Effects of shearing treatment and litter size or ewe age were also shown to be additive by Parker et al. (1991) and Sumner & Scott (1990).

Wool Production and Characteristics

Despite a similar rate of greasy midside wool growth before shearing, both greasy and clean wool growth rates were greater for shorn ewes than for unshorn ewes post-shearing. This is possibly related to the greater herbage intake of the shorn ewes over the post-shearing period. A similar, but less marked, trend in wool growth rate was measured in Chapter 3. Although wool growth rate was not recorded in Chapter 2, average annual fleeceweight was greater in pre-lamb shorn ewes than in December-shorn ewes in one of the two years of the experiment.

The fact that ewes shorn pre-lamb with a cover comb consumed less herbage than, but had similar wool growth rates to, ewes shorn pre-lamb by standard comb, may be related to the different pattern of liveweight change after shearing, as mentioned earlier. Lower heat production/heat expenditure in ewes shorn by cover comb than in ewes shorn by standard comb (Holmes et al. 1992) would allow a greater proportion of absorbed nutrients to be partitioned towards wool production.

Wool growth rate was not affected by litter size, particularly during the late pregnancy-lactation period. This is consistent with the results of Chapter 3 and those reported by Parker et al. (1991) and Parker & McCutcheon (1992) for the same breed of ewes and experimental area. The minimal effect of litter size on midside wool growth rates is also supported by the studies of Corbett (1979), Hawker (1985) and Morris et al. (1994b).

As expected, the yield and brightness of wool was greater for pre-lamb (July) shorn ewes than for post-weaning (November) shorn ewes. A similar difference between ewes shorn pre-lamb (August) and those shorn post-weaning (November) was observed by Story (1955, 1959), who found that the greater yield in the wool of pre-lamb shorn ewes was caused by a lower level of suint. Henderson (1965) suggested that the shorter wool of pre-lamb shorn ewes during the wet and warm conditions that are typical of spring was more readily washed of substances causing yellow discolouration than the longer wool of later shorn ewes. However, an effect of pre-lamb shearing on yellowness was not observed in the present study.

Lamb Survival and Production

Lamb survival was not affected by shearing treatment. This is in agreement with the results reported in Chapter 2, and of Everitt (1961) and Sumner & Scott (1990) who investigated the lambing performance of ewes shorn pre-lamb or post-weaning. The higher lamb losses in the present experiment than in the Riverside study (Chapter 2) were related to the colder and wetter conditions during spring 1992.

In agreement with the results reported in Chapters 2 and 3, lamb birthweight, docking weight and weaning weight were not affected by shearing treatment. The effects of shearing on lamb production have been discussed fully in earlier Chapters. However, it should be noted that the results presented here are consistent with those of other pre-lamb shearing trials in New Zealand (Orleans-Pobee & Beatson 1989; Parker et al. 1991), but not with those reported for trials with housed ewes in the United Kingdom (Maund 1980; Vipond et al. 1987; Black & Chestnutt 1990). The different environmental conditions (i.e. housing versus grazing) for these studies would have substantially influenced feed intake of the ewes and as a consequence could have directly affected placental development and subsequently lamb birthweight. In addition the time of shearing (more than 6 weeks before lambing vs 4 weeks in the present trial) would have contributed to inconsistency between results for these experiments (see Chapters 2 and 3 for a more complete discussion).

Rectal Temperature, Blood Metabolite and Hormone Concentrations of Ewes during Pregnancy

The lack of response in metabolite and hormone concentrations, and also rectal temperature, to shearing the day after shearing (S1) was probably related to the 24 hour fast ewes had been subjected to prior to shearing. Symond et al. (1989), who compared shorn and unshorn ewes over the last 4 weeks of pregnancy in either fed or under-fed conditions, reported that under-feeding removed any significant differences in lipid metabolism observed between shorn and unshorn groups in the fed state.

Rectal temperature (RT) was significantly lower in both groups of shorn ewes than in unshorn ewes on S3 which is consistent with greater cold stress in shorn ewes. However, by S5 only ewes shorn by standard comb had depressed rectal temperature while those of ewes shorn by cover comb were similar to the RT of unshorn ewes. This indicates that the cover comb-shorn group recovered more quickly than the standard comb-shorn group.

The lower RT of standard- and cover comb-shorn ewes on S3 was associated with increased circulating concentrations of glucose, 3OHB and NEFA in these groups, consistent with their need to mobilise body reserves in support of heat production. The associated increase in insulin concentrations in the shorn groups may have been stimulated by elevated circulating glucose concentrations or increased feed intake. A greater metabolic activity in shorn ewes than in unshorn ewes also was shown in other studies (Thompson et al. 1982; Russel et al. 1985; Astrup & Nedkvitne 1988; Symond et al. 1988a, b; Holmes et al. 1992).

Most of these differences between shorn and unshorn ewes had disappeared by S5 except for the increased 3OHB (both groups) and GH (standard comb group only) concentrations. The latter difference is consistent with a chronic adaptation to reduced energy balance and the need to mobilise body reserves in the standard comb-shorn group.

Plasma glucose concentrations were again increased on S20 in shorn ewes (particularly the standard comb-shorn group) compared with unshorn ewes. The higher glucose concentration at this time reflected a further period of cold and windy weather and was associated with a non-significantly higher GH concentration on S20. This indicates that standard shorn sheep still needed to mobilise body reserves when exposed to cold conditions, even after 20 days of wool growth post-shearing.

CONCLUSIONS

This experiment has shown differences in ewe and lamb productivity, particularly in ewe survival, liveweight change and wool growth/quality, between pre-lamb and post-weaning shorn ewes. Ewes shorn prior to lambing with a cover comb had greater tolerance to cold and wet conditions post-shearing than those shorn by a standard comb. The greater amount of residual wool and associated greater stubble depth left by the cover comb in comparison to the standard comb therefore provides a low cost practical method to mitigate the effects of inclement weather post-shearing. Also significant from a farm management viewpoint, is the fact cover comb shearing reduces the post-shearing increase in feed intake normally associated with the removal of the fleece. In the next Chapter a more detailed analysis of the effects of cover comb and standard comb shearing on metabolism of ewes is presented.

CHAPTER FIVE

EFFECTS OF SHEARING BY COVER COMB OR STANDARD COMB ON THE SHEEP'S RESISTANCE TO COLD, WINDY AND WET CONDITIONS

ABSTRACT

The effects of shearing by cover comb and standard comb were studied over two days pre-shearing and 10 days post-shearing in 8 pairs of non-pregnant, non-lactating two-year old ewes. Animals were housed and fed at a maintenance level on chaffed lucerne hay. One member of each pair was shorn with a cover comb, the other with a standard comb. Each pair was exposed to "cold plus wind" (7°C ambient temperature, 7 km/h air movement) followed by "cold plus wind plus rain" (10°C ambient temperature, 7 km/h air movement, wetting at a rate of 30 l/h from overhead sprinklers) in a calorimetry chamber on days S-3, S-2, S0 (day of shearing), S2, S6 and S10. Heat production was 22% greater in ewes shorn by the standard comb under conditions of "cold plus wind" and 38% greater under conditions of "cold plus wind plus rain" than in their cover comb-shorn cohorts. Circulating concentrations of non-esterified fatty acids were substantially elevated on the day of shearing and two days thereafter in ewes shorn by the standard comb, indicating increased rates of body fat mobilisation to support heat production in these ewes compared to those shorn by the cover comb. This was reflected in a 1.4 kg weight loss in the standard comb-shorn ewes compared with a 0.4 kg liveweight gain in the cover comb-shorn group over the 10 days of the experiment. It was concluded that use of a cover comb will significantly reduce the risk of death from hypothermia in sheep shorn during winter and spring, and should facilitate an increase in the productivity of animals by allowing a greater proportion of feed energy intake to be used for productive purposes.

INTRODUCTION

It was shown in Chapter Four that ewes shorn by cover comb prior to lambing exhibited greater resistance to cold stress than ewes shorn by standard comb when exposed to cold, wind and rain. During the 14 days post-shearing, 14% of ewes shorn by standard comb, but only 3% of ewes shorn by cover comb, died. Similarly ewe liveweight losses and feed intake responses after shearing were greater in ewes shorn by standard comb than in those shorn by cover comb. Contrary to the standard comb-shorn ewes, cover comb-shorn ewes had neither a loss of live weight after shearing nor a significantly increased feed intake relative to unshorn ewes. These results show that the potential disadvantages of pre-lamb shearing sheep by standard comb, including the risk of ewe losses through post-shearing cold stress and the need to supply additional pasture to meet increased post-shearing feed requirements, could be reduced or eliminated by using the cover comb shearing technique. These effects presumably occurred because the additional wool left on the sheep after shearing with a cover comb provided increased insulation against cold, wet and/or windy weather.

Recently an experiment was carried out at Massey University to compare the effect of a cold environment on sheep shorn by standard comb or by cover comb (Holmes et al. 1992). The results of that experiment showed that oxygen consumption (a measure of heat production and therefore of cold stress) was elevated to a greater extent and for a longer period of time following shearing by standard comb when compared with sheep shorn by cover comb. In general, during a period of 12 days after shearing, sheep shorn with the cover comb were 20% more resistant to cold conditions than sheep shorn with a standard comb. However, in that trial, measurements were made in still air and at 10°C ambient temperature. It is likely that, in situations when sheep are exposed to rain and wind together, the difference in cold resistance between those shorn by cover comb and those shorn by standard comb will be even larger. The objective of this study was therefore to compare the effect of different climatic conditions (temperature, wind and rain) on cold resistance of ewes shorn by standard comb vs cover comb.

MATERIALS AND METHODS

Experimental Design and Animals

The study involved a comparison of the effects of cover comb- and standard comb- shearing in 8 pairs of ewes studied over two days pre-shearing and 10 days post-shearing. Sixteen non-pregnant non-lactating Border Leicester x Romney (BLxR) two year old ewes were used in this experiment. Ewes were paired with respect to initial body weight and condition score. One member of each pair was randomly allocated to shearing treatment (i.e. shorn with a cover comb or standard comb on shearing day 0 = S0).

The ewes were kept in individual pens at the Animal Physiology Unit, Massey University, for two to three weeks prior to the measurements of oxygen consumption to adapt them to the new environment. During this period ewes were also housed in a simulated calorimeter chamber to allow them to become accustomed to the experimental chambers. Fasted ewe liveweights were measured at the start of the adaptation period. The fleece-free liveweights of ewes were also recorded on four days (S0, S2 , S6 and S10) immediately before animals were put into the calorimeter chamber. Ewes were fed on chaffed lucerne hay at a daily allowance of 0.5 MJ ME/ $kg^{0.75}$ which was calculated to be approximately 1.1 times their maintenance requirement (ARC 1980). The lucerne hay was assumed to contain 20% crude protein and 9.5 MJ ME/kg DM. Feed was given once daily at 1600 h and water was freely available at all times. During the trial the amount of feed offered to each ewe was individually recalculated after each recording of ewe liveweight.

Fleece Depth

Fleece depth of each pair was measured on the day of shearing (S0) and on days 2, 6 and 10 (S2, S6 and S10) after shearing, immediately before the animals were put in the calorimeter chamber. Fleece depths were measured with a ruler which was placed at the skin surface of 10 sites each on the back and midside of the animal. The average length of fleece stubble at these sites was used as the fleece depth measurement on each day.

Oxygen Consumption

Oxygen consumption was measured in two identical open circuit calorimeter chambers on a total of six measurement days, two days before shearing (S-3 and S-2) and four days after shearing (immediately after shearing (S0), and on days 2, 6 and 10 after shearing). On each measurement day, oxygen consumption was measured under two sets of climatic conditions (cold plus wind followed by cold plus wind plus wet). During the measurement period each component of the climatic conditions was held at a steady state (ambient temperature at 7°C and 10°C when sheep were exposed to wind and wind plus rain respectively). The rate of air movement ("wind") was held at 7 km/h and the flow rate of water held at 30 l/h (equivalent to rain fall of 25 mm/h) according to the method described by Holmes & McLean (1975). Sheep were exposed to rain from overhead sprinklers and water flow was more than sufficient to saturate the animal's coat. As shown in Table 5.1, sufficient time was allowed after each change in climatic conditions to ensure that oxygen consumption had stabilised to the new conditions before it was again measured. Sheep were housed in the calorimeter chambers for 23-24 hours on each measurement day (Table 5.1). The details of instruments for measurement of oxygen consumption and other characteristics of the calorimeter chambers were described by Holmes (1973).

Heat Production, Body Insulation and Lower Critical Temperature

Heat production (HP) was calculated using the equation of McLean (1972):

$HP = 20.46\ V\ O_2.$

where HP= heat produced (MJ/24 hr)

and $V\ O_2$ = oxygen consumed (l/24 hr).

Maximum body insulation (BI_{Max}) was calculated after shearing for the measurement of oxygen consumption using the equation described by Holmes et al. (1992):

$BI_{Max} = (RT - AT) / (HP/SA).$

where:

RT = rectal temperature (°C)

AT = air temperature (°C)

HP = heat production measured below the lower critical temperature.

SA = surface area of sheep (in m^2) calculated using the equation SA= 0.098 x body weight $(BW)^{0.633}$, where body weight is measured in kg (Brody 1945).

Lower critical temperature (LCT) was calculated using the equation of Blaxter (1977):

$LCT = RT - (BI_{Max} \times HP/SA_{Min}).$

where the HP/SA_{Min} is the minimal heat production per unit surface area (i.e. that measured under thermoneutral conditions before shearing)

Plasma Metabolite Concentrations

Blood samples from each pair of ewes were collected on the day of measurement of oxygen consumption, immediately after animals were taken out of the calorimeter chamber (i.e. at 1500 h, Table 5.1). Blood samples (10ml) were withdrawn by venipuncture from the external jugular vein using EDTA vacutainers (Nipro Industries, Japan). These were immediately placed in crushed ice, until the blood plasma could be separated by centrifugation at 3000 g for 20 minutes. Plasma samples were stored at -20°C until analysis. Plasma concentrations of glucose and non-esterified fatty acids (NEFA) were analysed using the procedures described in Chapter Four.

Rectal Temperature

The rectal temperature of ewes was recorded immediately after blood samples had been obtained. Measurements were made by inserting a digital thermometer (Becton Dickinson, Ontario, Canada) to a depth of approximately 5 cm into the rectum for about 2 minutes until a constant recording was achieved.

Statistical Analysis

Because the "wind plus wet" treatment always followed the "wind only" treatment (due to the fact that the reverse sequence would not have allowed time for the fleece to dry within the 24 h measurement period), climatic treatment and sequence were confounded. Hence data for the two climatic treatments were analysed separately. Liveweight, fleece depth, heat production, rectal temperature and blood metabolite concentrations of ewes were subjected to analysis of variance at each measurement time to test the effect of shearing treatment (standard comb vs cover comb). The liveweight of ewes recorded at shearing (S0) and the pre-shearing values of heat production, rectal temperature and blood metabolite concentrations were used as covariates for these parameters.

Table 5.1 Sequence of events on each measurement day

1530h	Chambers cleaned Feed put in for new sheep Liveweight and fleece depth of sheep measured
1600h	Sheep into calorimeter chambers
1600-1030h	Sheep exposed to 7°C + Wind Oxygen consumption measured (0830h-1030h)
1030-1500h	Sheep exposed to 10°C + Wind + Rain Oxygen consumption measured (1300h-1500h)
1500h	Sheep removed from chambers Blood sample collected Rectal temperature measured.

RESULTS

Liveweight, Fleece Depth and Rectal Temperature

The fleece-free liveweights of sheep exposed to cold conditions at four times after shearing are given in Table 5.2. The liveweights of sheep immediately after shearing (S0), but before they were put into the calorimeter chambers, were not significantly different between shearing groups. However, during the ensuing 10 days, sheep shorn by standard comb lost weight while those shorn by cover comb gained weight. As a result, liveweights were significantly ($P<0.05$) greater in sheep shorn by cover comb than in those shorn by standard comb on days S2, S6 and S10.

Fleece depths and rectal temperatures of sheep are also shown in Table 5.2. The fleece depth in sheep shorn by cover comb was significantly ($P<0.01$) greater than that in sheep shorn by standard comb on all measurement days. The rectal temperatures were similar for both shearing groups.

Heat Production, Body Insulation and Lower Critical Temperature

The calculated heat production, body insulation and lower critical temperature of sheep are given in Tables 5.3, 5.4 and 5.5 respectively.

Heat production was significantly greater in the standard comb-shorn group than in the cover comb-shorn group on all post-shearing measurement days ($P<0.001$ on day S0 and S2; $P<0.05$ on day S6 and S10). As expected, the magnitude of the difference in heat production between the two shearing groups was greater when sheep were exposed to wind plus rain rather than wind only.

Table 5.2 **Effect of shearing treatment (standard vs cover comb) on fleece-free liveweight (LW), rectal temperature (RT) and fleece depth (FD) of sheep exposed to cold conditions on day 2 prior to shearing and on days 0, 2, 6 and 10 post-shearing (Mean±SEM).**

	LW (kg)[1]		RT (°C)		FD (mm)	
	Standard	Cover	Standard	Cover	Standard	Cover
Day[2]						
S-2	-	-	39.0±0.1	38.8±0.1	-	-
S0	41.2±1.2	40.8±1.2	38.8±0.2	38.7±0.2	3.1±0.2[a]	5.1±0.2[b]
S2	40.2±0.2[a]	40.9±0.2[b]	38.8±0.1	38.8±0.1	3.9±0.2[a]	6.1±0.2[b]
S6	40.0±0.3[a]	41.0±0.3[b]	38.9±0.1	38.8±0.1	5.6±0.4[a]	8.0±0.4[b]
S10	39.8±0.3[a]	41.2±0.3[b]	39.0±0.1	38.9±0.1	7.3±0.4[a]	9.8±0.4[b]

1 Liveweight on day of shearing (S0) was used as a covariate for subsequent measurement days.
2 Day relative to shearing.
ab Means within rows and traits having superscripts with letters in common are not significantly different (P>0.05).

The decline in heat production as the study progressed was associated with a progressive increase in stubble depth and in body insulation (Table 5.2 and 5.4) and a decrease in lower critical temperature (Table 5.5). All of these parameters were significantly affected by shearing treatment throughout the study.

Plasma Metabolite Concentrations

Plasma concentrations of glucose and non-esterified fatty acids (NEFA) were measured once before shearing (S-2) and on 4 days after shearing (S0, S2, S6 and S10), see Table 5.6.

Plasma concentrations of glucose were similar between shearing groups on all measurement days.

Plasma concentrations of NEFA were significantly greater in sheep shorn by standard comb than in sheep shorn by cover comb on S0 ($P<0.01$) and S2 ($P<0.10$) but not on other measurement days.

Table 5.3 Effect of shearing treatment (standard vs cover comb) on heat production (MJ/24 hr) of sheep exposed to cold conditions, either wind or wind+rain, on days 3 and 2 prior to shearing and on days 0, 2, 6 and 10 post-shearing (Mean±SEM).

	Wind		Wind+Rain	
	Standard	Cover	Standard	Cover
Day[1]				
S-3[2]	6.94±0.22	6.86±0.22	-	-
S-2[3]	6.85±0.23	6.73±0.23	8.60±0.42	7.47±0.42
S0	13.41±0.36[b]	10.98±0.36[a]	19.69±0.63[b]	14.31±0.63[a]
S2	12.72±0.33[b]	10.33±0.33[a]	16.75±0.56[b]	13.36±0.56[a]
S6	11.55±0.33[b]	9.82±0.33[a]	15.88±0.68[b]	12.92±0.68[a]
S10	10.01±0.33[b]	8.67±0.33[a]	14.24±0.74[b]	11.78±0.74[a]

1 Day relative to shearing.
2 At 3 days prior to shearing (S-3) sheep were exposed only to wind.
3 Heat production 2 days prior to shearing (S-2) was used as a covariate for subsequent measurement days.
ab Means within rows and climatic conditions (wind or wind+rain) having superscripts with letters in common are not significantly different ($P>0.05$).

Table 5.4 **Effect of shearing treatment (standard vs cover comb) on body insulation (°C/MJ/m^2) of sheep exposed to cold conditions, either wind or wind+rain, on days 0, 2, 6 and 10 post-shearing (Mean±SEM).**

	Wind		Wind+Rain	
	Standard	Cover	Standard	Cover
Day[1]				
S0	2.5±0.1^a	3.0±0.1^b	1.5±0.1^a	2.1±0.1^a
S2	2.6±0.1^a	3.2±0.1^b	1.8±0.1^a	2.2±0.1^b
S6	2.8±0.1^a	3.4±0.1^b	1.9±0.1^a	2.3±0.1^b
S10	3.2±0.1^a	3.9±0.1^b	2.1±0.1^a	2.6±0.1^b

1 Day relative to shearing.
ab Means within rows and climatic conditions (wind or wind+rain) having superscripts with letters in common are not significantly different (P>0.05).

Table 5.5 Effect of shearing treatment (standard vs cover comb) on lower critical temperature (°C) of sheep exposed to cold conditions, either wind or wind+rain, on days 0, 2, 6 and 10 post-shearing (Mean±SEM).

	Wind		Wind+Rain	
	Standard	Cover	Standard	Cover
Day[1]				
S0	22.2±0.5[b]	18.5±0.5[a]	27.5±0.5[b]	23.3±0.5[a]
S2	21.6±0.5[b]	17.3±0.5[a]	25.7±0.6[b]	22.2±0.6[a]
S6	19.8±0.7[b]	16.1±0.7[a]	24.9±0.7[b]	21.5±0.7[a]
S10	17.0±0.9[b]	12.8±1.0[a]	23.3±1.0[b]	19.5±1.0[a]

1 Day relative to shearing.
ab Means within rows and climatic conditions (wind or wind+rain) having superscripts with letters in common are not significantly different (P>0.05).

Table 5.6 Effect of shearing treatment (standard vs cover comb) on plasma glucose and non-esterified fatty acid (NEFA) concentrations of sheep exposed to cold conditions (wind+rain) on day 2 prior to shearing and on days 0, 2, 6 and 10 post-shearing (Mean±SEM).

	Glucose (mmol/l)		NEFA (meq/l)	
	Standard	Cover	Standard	Cover
Day[1]				
S-2[2]	3.94±0.18	3.91±0.18	0.37±0.09	0.37±0.09
S0	4.25±0.15	4.20±0.15	1.20±0.08[b]	0.59±0.08[a]
S2	4.18±0.20	4.30±0.20	0.81±0.10	0.55±0.10
S6	4.26±0.12	4.19±0.12	0.57±0.06	0.48±0.06
S10	4.29±0.12	4.19±0.12	0.46±0.06	0.51±0.06

1 Day relative to shearing.

2 Metabolite concentration 2 days prior to shearing (S-2) was used as a covariate for subsequent measurement days.

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

DISCUSSION

The principle of indirect calorimetry requires that animals be maintained in climatic conditions which permit the maintenance of a constant deep body temperature. Thus changes in body energy storage are negligible and heat production (in this case measured by oxygen consumption) can be taken as an accurate indicator of rates of body heat loss. This condition was satisfied in the present experiment, the climatic conditions to which the ewes were exposed (including the combination of cold plus wind plus rain) being such that rectal temperatures were not significantly different between the standard comb- and cover comb-shorn sheep (Table 5.2). Climatic conditions were thus less severe than in the previous field study (Chapter 4), in which a substantial proportion of the ewes shorn with a standard comb became hypothermic and subsequently died. However, they were more extreme than those used in the previous calorimetry study in which sheep were exposed to still air at 10°C (Holmes et al. 1992).

The beneficial effects of shearing with a cover comb are illustrated by comparative rates of heat production in the two groups of ewes. When ewes shorn by the standard or cover comb were exposed to cold and wind, rates of heat production were significantly elevated in the standard comb-shorn group until completion of the experiment ten days after shearing. This is consistent with the results reported by Holmes et al. (1992). The unique feature of the present study was, however, the application of more extreme conditions in the form of cold plus wind plus rain. Under these conditions, differences between the two shearing treatments were substantially greater than those under the more mild conditions. Thus, for example, rates of heat production were 22% greater in ewes shorn by the standard comb under conditions of "cold plus wind" but 38% greater under conditions of "cold plus wind plus rain" on the day of shearing (S0). In absolute terms, the difference was approximately 2.4 MJ/24h under "cold plus wind" but 5.4 MJ/24h under "cold plus wind plus rain".

Deaths of ewes following pre-lamb shearing are primarily caused by hypothermia, i.e. situations in which the maximum capacity of the ewe for heat production ("summit metabolism") is exceeded by rates of heat loss to the environment with the result that, in extreme situations, deep body temperature falls uncontrollably. Since summit metabolism of individual animals is essentially fixed, this problem can be resolved only by reducing rates of heat loss. The benefits of pre-lamb shearing with a cover comb as opposed to a standard comb can therefore be inferred from rates of heat production as shown in Table 5.3. The substantially lower rates of heat production in ewes shorn with the cover comb imply that their rates of heat loss under extreme conditions would also be much lower with the result that they would be far less likely to become hypothermic.

In addition to causing acute lethal hypothermia, pre-lamb shearing can affect the productivity of ewes. Thus when rates of body heat loss are high, a greater proportion of the animal's energy intake must be diverted to maintaining high levels of heat production (and hence deep body temperature) rather than to productive purposes such as liveweight gain, wool growth and lamb production. The results of this study emphasise the benefits of cover comb-shearing in this context. In particular circulating concentrations of NEFA were substantially elevated on the day of shearing and two days thereafter in ewes shorn by the standard comb as shown in Table 5.6. Increased circulating concentrations of NEFA are indicative of increased rates of body fat mobilisation to support heat production. These differences were in turn associated with differences in liveweight gain. Thus ewes shorn with the cover comb increased body weight over the ten days of the experiment while those shorn with the standard comb lost weight. The difference in weight change between the two groups (a loss of 1.4 kg in the standard comb group versus a gain of 0.4 kg in the cover comb group) is substantial when one considers that, during the ten days of the experiment, animals were in the calorimetry chambers for only four days and were held under housed conditions for the remaining six days.

CONCLUSIONS

The results of this experiment indicate that shearing with a cover comb can reduce energy expenditure by up to 40% in situations of moderate (i.e. nonlethal) cold compared to shearing with a standard comb. Use of a cover comb will therefore significantly reduce the risk of death from hypothermia and increase the longer term productivity of animals by allowing a greater proportion of feed energy intake to be used for productive purposes.

CHAPTER SIX

GENERAL DISCUSSION

The main objective of this research programme was to investigate issues relating to the development of the pre-lamb shearing policy as a means of improving productivity of, and financial returns to, New Zealand sheep farming systems.

Although several advantages and disadvantages have been claimed for pre-lamb shearing relative to conventional (post-weaning) shearing (see Chapter 1), these have not been extensively studied under New Zealand conditions. Likewise, the use of the cover comb to ameliorate effects of post-shearing cold-stress, and the role of pre-lamb shearing in out-of-season lambing systems, have received little attention. A series of studies were therefore conducted in this programme to address these issues. It is the objective of this Chapter to summarise the results of these studies, in terms of the advantages and disadvantages of pre-lamb shearing, and to examine likely financial returns to farmers from adoption of this policy.

ADVANTAGES OF PRE-LAMB SHEARING

Wool Production and Quality

As in previous studies (Story & Ross 1960; Everitt 1961; Sumner & Scott 1990) effects of pre-lamb shearing on fleeceweight and clean wool growth were inconsistent but generally in favour of pre-lamb shorn ewes. In Experiment 1 (Chapter 2), annual fleeceweight was greater in pre-lamb shorn ewes in 1990 but not in 1991. This difference was associated with greater pasture allowances in the spring/summer of 1989/1990 (i.e. the period preceding 1990 shearing) than in 1990/1991 (preceding the 1991 shearing). Likewise in Experiment 2 (Chapter 3), midside wool growth rate

(P118-L13) was greatest in pre-lamb shorn May-lambing ewes but was not affected by pre-lamb shearing in August-lambing ewes. This difference was again associated with a difference in pasture allowance, SSH being greater over P112-P140 (and to a lesser extent over L0-L33) for May-lambing than for August-lambing ewes. Greater DMI and OMI (but significant only on P119 and P121) were observed in pre-lamb shorn than in unshorn ewes in the May-lambing group. Over the period P110-L40, midside wool growth rates were greater in ewes shorn by standard or cover comb than in unshorn ewes in Experiment 3 (Chapter 4). This response was associated with a greater ($P<0.10$) feed intake in the standard comb-shorn group and a non-significantly greater intake in the cover comb-shorn group compared with unshorn ewes over the immediate post-shearing period (P123-126). Taken together, these results suggest that responses in wool growth to pre-lamb shearing may be greatest when feed allowances in the post-shearing period are high (although in Experiment 3, responses in wool growth were observed in the absence of marked responses in feed intake).

Pre-lamb shearing had no effect on fibre diameter (Experiment 2 and 3) but did increase yield and brightness of wool (Experiment 3) consistent with previous reports (Coop 1950; Story 1955; Story & Ross 1960; Henderson 1965; Sumner et al. 1982).

It can thus be concluded that the effects of pre-lamb shearing on wool production and value are likely to be positive, if they exist at all, but will occur at the expense of increased feed intake at a time when, at least in spring - lambing ewes, pasture supplies are limited. The relationship between wool growth responses and pasture allowance is likely to be positive, based on the results of this study, but is yet to be assessed in a controlled experiment (i.e. by exposing pre-lamb shorn ewes to different pasture allowances or sward surface heights in late pregnancy and/or early lactation, and measuring wool growth responses). This would be a useful focus of future studies.

Lamb Production and Survival

Lamb production (birthweight, weaning weight, growth rate) and survival recorded in Chapters 2, 3 and 4 were not affected by the dam's shearing treatment.

The possible reasons for differences in pre-lamb shearing effects on lamb production between New Zealand studies (Orleans-Pobee & Beatson 1989; Parker et al. 1991; this study), which generally show no effect, and overseas studies (Maund 1980; Salman and Owen 1986; Symonds et al. 1986; Vipond et al. 1987; Phillips et al. 1988; Black & Chestnutt 1989, 1990), in which lamb birthweight and growth rate were commonly increased by pre-lamb shearing, have been discussed previously and need not be considered again here. Suffice it to say that, although pre-lamb shearing influences ewe feed intake and body condition, it does not, under the conditions of New Zealand studies, influence lamb growth or survival. Nor does it overcome the low growth in utero, and hence low birthweights, of lambs born to autumn- vs spring-lambing ewes (Chapter 3). However, this does not preclude the possibility that a greater interval between pre-lamb shearing and parturition might increase lamb birthweights (because of the opportunity for delayed responses in ewe feed intake to influence foetal growth) or that pre-lamb shearing close to parturition might increase lamb survival on exposed hill country by encouraging recently shorn ewes to seek shelter for themselves and their lambs (Alexander & Lynch 1976). These are aspects of pre-lamb shearing which warrant further study.

Management Issues

The reduced labour requirements due to less time needed for assisting cast sheep during lambing and lower shearing costs through the elimination of pre-lamb crutching were two management benefits of pre-lamb shearing which were considered informally in Experiment 1 (Chapter 2). These benefits are consistent with the results of other New Zealand studies (Coop 1950; Story 1955; Frengly 1964; Parker & Gray 1989) and, along with several other management parameters not examined in this study, are addressed later in this Chapter.

DISADVANTAGES

Ewe Losses

As in previous studies (Hutchinson & McRae 1969; Sumner & Scott 1990), effects of pre-lamb shearing on ewe losses were inconsistent between years and were apparently influenced by climatic conditions immediately after shearing. Losses were similar between pre-lamb and conventionally shorn ewes in Experiment 1 (Chapter 2) but greater in pre-lamb shorn ewes in Experiment 3 (Chapter 4). This inconsistency reflected the more adverse weather conditions (cold, wind and rain) experienced by ewes immediately post-shearing in Experiment 3.

The majority of ewe losses occurred within two weeks of shearing. A similar result was recorded by Hutchinson & McRae (1969) when adverse climatic conditions were encountered during a 12-day period after shearing. Elvidge & Coop (1974) also noted that behavioural adjustments of shorn sheep for heat conservation (e.g. postural adjustment, wrinkling of skin, and shivering) were diminished in intensity from the second week after shearing. This likely reflects the regrowth of wool, and hence increase in body insulation, over the first few weeks post-shearing (Chapter 5).

In Experiment 3, when ewes experienced adverse climatic conditions after shearing, a substantially increased ewe loss rate was observed for ewes pre-lamb shorn by standard comb, while losses were similar in those pre-lamb shorn by cover comb and ewes not shorn until weaning. The lower ewe losses in the cover comb-shorn group than in the standard comb-shorn group reflected their greater residual wool depth post-shearing which increased insulation against cold conditions (see later discussion). Similarly, lower ewe losses and heart rates, but greater rectal and skin temperatures (reflecting improved heat conservation) were recorded for snow comb-shorn vs standard comb-shorn sheep by Hutchinson et al. (1960). Thus use of the snow or cover comb has the potential to substantially reduce ewe loss rates during periods of inclement weather immediately after shearing.

Body Temperature Changes

In Experiment 3, rectal temperature was significantly lower in both pre-lamb shorn groups of ewes than in unshorn ewes. This is consistent with greater cold stress in the shorn ewes which was reflected in their greater circulating concentrations of glucose, 3OHB and NEFA. These changes in circulating metabolite concentrations in turn reflect mobilisation of body reserves in support of elevated heat production.

By 5 day after shearing only ewes shorn by standard comb had depressed RT while ewes shorn by cover comb had similar RT to the ewes left unshorn until weaning. This indicates that the cover-comb shorn group recovered more quickly than the standard comb-shorn group. This difference between the two pre-lamb shorn groups was associated with greater feed intake responses and liveweight losses in the standard comb-shorn group during the immediate post-shearing period.

Ewe Feed Intake

The greater post-shearing feed intake of pre-lamb shorn ewes measured in Experiments 2 and 3 (Chapters 3 and 4) was in general agreement with the results of several shearing studies (Coop & Drew 1963; Wheeler et al. 1963; Wodzicka-Tomaszewska 1963, 1964; Webster & Lynch 1966; Elvidge & Coop 1974; Love et al. 1978; Maund 1980; Morgan & Broadbent 1980; Salman & Owen 1986; Vipond et al. 1987; Black & Chestnutt 1990; Parker et al. 1991), but the responses of feed intake to shearing varied in terms of timing, duration and magnitude. Feed intake response was also influenced by method of shearing (cover comb and standard comb).

In Experiment 2 (Chapter 3) the feed intake immediately after shearing (P119-130) was not affected by shearing treatment, but pre-lamb shorn ewes had greater intakes over P141-144. This delay in response of feed intake is consistent with the results of several studies (Wodzicka-Tomaszewska 1963, 1964; Webster & Lynch 1966; Weston 1970; Donnelly et al. 1974; Hawker et al. 1985; Phillips et al. 1988) which indicated a lag of feed intake response by up to 2 to 3 weeks after shearing. This suggests that, immediately after shearing in cold conditions, sheep cannot increase their intake to match their greater energy demands. The lag in intake response may be partly a consequence of changes in behaviour (e.g. sheltering) which favour heat conservation at the expense of increased grazing time and feed intake in shorn ewes (Hutchinson & McRae 1969; Davey & Holmes 1977; Done-Currie 1980).

Feed intake was significantly greater in pre-lamb shorn ewes when measured about 3 weeks (P141-144) and more than 1 week (P123-126) after shearing in Experiments 2 and 3 respectively. Feed intake was not affected by shearing treatment over three measurement periods during lactation (L8-11, L21-25 and L29-33). These results indicate that significant responses in feed intake to shearing were exhibited only for a short period (10-20 days after shearing during pregnancy). This short duration in increased feed intake response to shearing is in contrast with the result of several shearing studies conducted with non-pregnant sheep (Wodzicka-Tomaszewska 1963,1964; Hutchinson & McRae 1969; Weston 1970). In those studies, the increase in feed intake after shearing remained for 7-12 weeks. The shorter duration of responses in pregnant sheep may be a consequence of their greater resting heat production and hence generally greater resistance to cold-stress (see Chapter 1).

During the period of maximum differences in feed intake, pre-lamb shorn ewes had 12% and 17% greater intakes than unshorn ewes in Experiments 2 and 3 respectively. This difference indicates that the magnitude of increased feed intake in pre-lamb shorn ewes was considerably less than the equivalent results recorded in other shearing trials for non-pregnant ewes or pregnant ewes in indoor conditions (Wheeler et al. 1963; Wodzicka-Tomaszewska 1963, 1964; Hutchinson & McRae 1969; Elvidge & Coop 1974; Weston 1982). However the difference of 12-17% was compatible with the results of previous studies examining effects of pre-lamb shearing on intake in grazing/ outdoor conditions and a similar climate (Hudson & Bottomley 1978; Parker et al. 1991).

Liveweight and Body Condition

Shorn ewes generally had lower liveweight gain or greater liveweight loss and lower back fat depth (BFD) immediately after shearing. Pre-lamb shorn ewes had lower BFD (0.8 mm) at P142 (S24) in Experiment 2 and negative liveweight gain (0.9 kg) over P110-P134 (S-3 to S21) in Experiment 3 than unshorn ewes. These results, and those from the measurement of blood metabolite concentrations, are consistent with a greater mobilization of body reserves by shorn ewes to support their increased heat production. Furthermore, when two methods of pre-lamb shearing were compared, only ewes shorn by standard comb had liveweight losses, while ewes shorn by cover comb either maintained their liveweight during the post-shearing period (P110-P134, Experiment 3) or had a slight liveweight gain over the 10 days after shearing (Experiment 4).

EFFECT OF COVER COMB VS CONVENTIONAL COMB

As noted earlier in this discussion, ewes shorn by cover comb prior to lambing had higher survival rates, higher rectal temperatures and lower feed intakes than those shorn by standard comb. These differences clearly reflected the greater residual wool depth left by the cover comb and the associated improvement in body insulation and reduced requirement for energy expenditure to maintain deep body temperature.

These results indicate that use of the cover comb should be strongly supported as a means of increasing ewe survival and improving productivity. Furthermore, the fact that ewes shorn by cover comb in Experiment 3 were able to maintain body temperature without markedly increasing feed intake suggests that the provision of additional feed post-shearing may be less critical for ewes shorn by this method compared with those shorn by the standard comb. At present farmers do not have clear targets for SSH which should be offered to ewes post-shearing to maximise survival and productivity. The results of this study suggest that these targets will differ depending on whether or not the cover comb is used, and this is an area which requires further investigation.

SHEARING AND SEASONAL LAMBING POLICY

Regardless of shearing treatment, May-lambing ewes had greater wool production (quantity and quality) associated with a more even pattern of wool growth rates than August-lambing ewes. On the other hand August-born lambs were heavier at birth and weaning than May-born lambs. These results are in agreement with the results of other studies of out-of- season lambing (Reid et al 1988; Notter & McClaugherty 1991; Reid & Sumner 1991; Morris et al.1993a, 1994a).

In general feed intake and productivity responses to pre-lamb shearing were similar between both lambing policies, except for wool growth rates which were influenced by shearing to a greater extent in May- than in August- lambing ewes. Thus the results of this study indicate that effects of shearing treatment and lambing policy were additive in most respects, suggesting that the advantages and disadvantage of pre-lamb shearing spring-lambing ewes are also likely to apply to autumn- lambing ewes.

FINANCIAL CONSIDERATIONS

In this section the whole farm implications of a pre-lamb shearing policy are considered. Results of the component experimental work reported in Chapters 3 to 5, and the preliminary on-farm investigation of pre-lamb shearing reported in Chapter 2, are interpreted in relation to 1993 costs and prices for farm inputs and outputs.

In order to achieve this, a partial budget was prepared to quantify the difference, and hence the net change in returns per ewe, between a pre-lamb shearing policy (based on use of the cover comb) and a conventional (post-weaning) ewe shearing policy (Table 6.2) for spring-lambing ewes. The production parameters used in the partial budget were established from the experimental results reported in Chapters 2 to 5 of this thesis (Table 6.1).

To estimate the wool price differential between the two shearing policies, auction prices for September and December wool sales were reviewed for the last five years (Wool Market Review 1989-1993). The average auction price for wool from each policy, calculated from the four sales in each month, is illustrated in Figure 6.1. These data indicate that prices have been consistently higher for wool which is presumed to come mainly from pre-lamb shorn ewes (sold in September) than for wool harvested later in the year (and sold in November/ December). The data also show that there has been considerable fluctuation in the price margin between wool sold in September and December since 1989. The 5-year average fleece price for wool assumed to be derived from pre-lamb and conventional shearing was \$4.52 and \$4.13/kg clean wool respectively. The corresponding values for pieces, bellies and crutchings (P&B&C) were \$3.76 and \$3.50/kg clean wool.

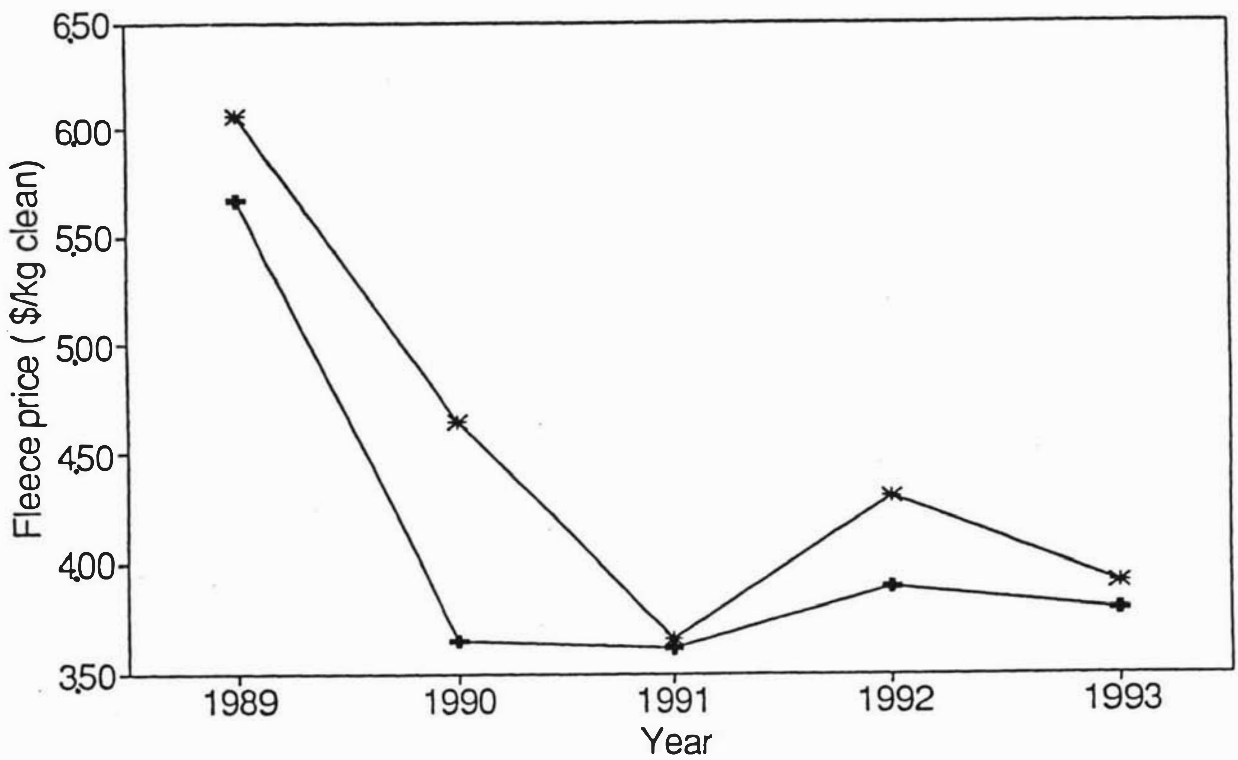

Figure 6.1 Clean price ($/kg) for wool (type 35 F2D) sold in either September (assumed to be from pre-lamb shearing) or December (assumed to be from conventional shearing) by auction between 1989 and 1993. (*) September, (+) December. (Source: New Zealand Wool Board Annual Wool Market Reviews 1989-93).

The 5-year average difference between the September and December sales for fleece ($0.39/kg) and P&B&C ($0.26/kg) was considerably higher than the 1993 values of $0.12 and $0.19/kg, respectively. Moreover, in selecting the historical price data it was assumed for direct comparative purposes that both policies produced wool of similar colour (4-5 yellowness index), staple length (125 mm) and fibre diameter (35 μ). In practice, both colour and staple strength are likely to be superior for pre-lamb shorn ewes and these attributes could increase the price differential shown in Figure 6.1 (see Chapters 1 and 4). Only wool price data for 1993 were used in the partial budget. Other assumptions for the partial budget calculation were:

1. The annual proportion of clean fleece and P&B&C was 85 and 15%, respectively.

2. An average weighted price advantage of $0.13/kg clean wool was applied to the pre-lamb ewe clip, i.e. ($0.12/kg x 0.85 fleeceweight) + ($0.19/kg x 0.15 fleeceweight (P&B&C) = $0.13/kg clean).

3. On an annual basis more wool was lost through the death of ewes shorn post-weaning than those shorn pre-lamb (2% of ewe deaths x average weight of fleece at the time of death which was assumed to be an interval of 8 months since the last shearing). The majority of ewe losses on a sheep farm typically occur over the lambing to weaning period. Pre-lamb shearing removes wool immediately prior to this period and hence reduces overall losses in wool production through ewe deaths in comparison to a conventional post-weaning shearing policy (assuming, as was done here, that ewes are shorn pre-lamb with the cover comb rather than with the standard comb).

Whole Farm Cashflow Budget Analysis

Sumner (1985), and Parker & Gray (1989) both indicated that the timing of returns from the sale of the wool clip, and the quality of the wool offered for sale due to the type of shearing policy, were likely to have a larger effect on net sheep returns via changes in the monthly cashflow than through changes in ewe productivity per se. To consider the cashflow implications of pre-lamb shearing relative to a post-weaning shearing policy, and to estimate the savings per ewe in current account interest charges for the partial budget (Table 6.2), the time of ewe wool sales and the payment of shearing expenses were altered for an example sheep and beef cattle farm cashflow budget (Parker 1993, Table 7). The case farm wintered 1951 sheep stock units (SSU) of which 1000 were mixed age ewes. Two clear points emerged in terms of the cashflow patterns generated (Figure 6.2). The cashflow was improved over the spring and summer by pre-lamb shearing and, because of this, annual profit was improved by $ 209/year ($0.21/ mixed age ewe pre-lamb shorn) for the pre-lamb shearing policy through savings in current account interest charges (set at 10% p.a.). Thus, the time of pre-lamb shearing has important advantages for cash management even when interest charges for overdraft facilities are relatively low (in contrast to the 18% at the time of the analysis reported by Parker and Gray (1989)) and income from wool is low in comparison to that from sheep meat and beef (as in the 1993, financial year for example). The magnitude of the cashflow advantage on individual properties due to a change to pre-lamb shearing will also depend on the size of the ewe flock relative to other enterprises on the farm and the value ($/kg clean) of the wool sold. Thus the financial advantage of pre-lamb shearing is likely to be positively associated with increases in the sheep: cattle ratio, the proportion of the annual wool clip that is ewe wool, and the value of the fleece.

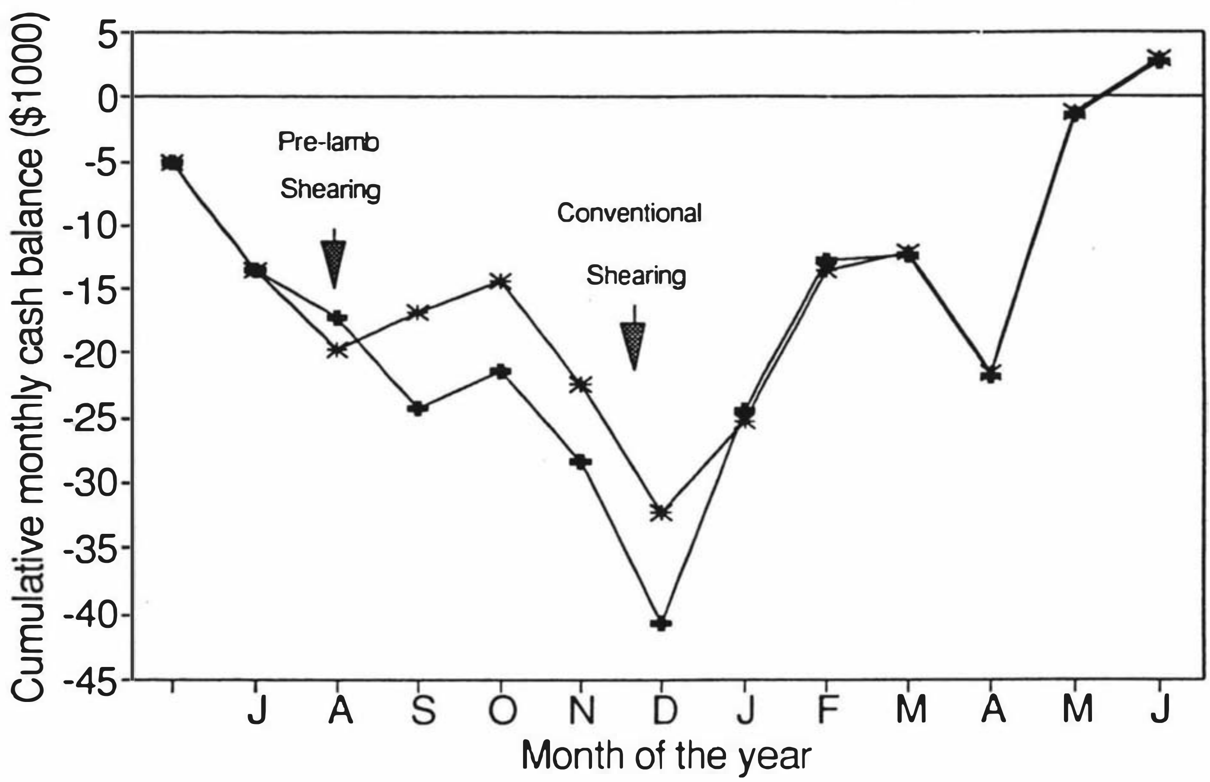

Figure 6.2 **Average monthly cashflow from July to June 1993 for a sheep and cattle farm wintering 1951 stock units and shearing 1000 mixed age ewes either prior to lambing (*) or after weaning (+). Current account interest is assumed to be charged at 10% pa. Based on cashflow budget of Parker (1993).**

Table 6.1 Production and financial parameters for a partial budget comparison of pre-lamb shearing by cover comb and conventional shearing (post-weaning).

Item	Base situation (Conventional)	Effect of change to pre-lamb shearing(±)
Sheep performance		
Ewe losses %		
Pre-lamb shearing to weaning	3.5	0
Weaning to pre-lamb shearing	1.5[1]	0
Lambing (%, lambs/ewe at shearing)		
Lambs born	142	0
Lambs docked	131	0
Lambs weaned	126	0
Lamb weaning weight (kg)	21.5	0
Annual wool production (kg)		
Greasy wool/ewe	3.70	+0.15
Greasy wool/lamb	1.0	0.0
Wool yield (%)	79	+4
Feed intake (kg/d DM)[2]	1.7	0.1
Financial		
Prices		
Fleece ($/kg clean wool)	3.80	+0.12[3]
P&B&C ($/kg clean wool)	3.01	+0.19
Ewe ($/head)	30.0[4]	0.00
Lamb ($/head)	35.0	0.00
Costs ($/ewe)		
Shearing	1.60	0.00
Pre-lamb crutch	0.55	-0.55
Pre-mate crutch	0.15	0.00
Other crutching	0.00	+0.15[5]

1 Annual ewe losses in a commercial flock over this period are typically between 1 and 3 %.

2 See Table 4.3, Chapter 4. Measured increases in feed intake by ewes pre-lamb shorn with a cover comb, while small and statistically non-significant, have been greater than those of unshorn ewes and for practical management purposes an allowance for extra feed consumption by ewes is appropriate.

3 See Figure 6.1 for summary of past 5 years.

4 Average ewe price over a 12 month period. Differences in the value of the fleece on ewes at the time of sale between the two shearing policies are assumed to balance out over a 12 month period.

5 Approximately 40% of ewes shorn in August require "dagging" (ie. a ring crutch) by December main-shear.

Table 6.2 Partial budget calculation showing the effects of changing from post-weaning to pre-lamb ewe shearing on a sheep farm.

Assumptions: The following calculations are based on a flock of 1000 mixed age ewes pre-lamb shorn each year in August, rather than in late November/ December under a traditional main shear policy.

Advantages:	
1. Increase in annual income	**$**
Extra wool returns due to $0.13/kg clean wool price advantage	
(3.70 kg x 0.83 yield x 1000 ewes x $0.13/kg)	39.92
Extra wool returns due to 0.15 kg greater annual fleeceweight	
(0.15 kg x 0.83 yield x 1000 ewes x $3.81[1]/kg)	474.35
Extra wool returns due to time of ewe losses	
(1000 ewes x 2% losses x 2.56[2] kg x 0.83 yield x $3.81[1]/kg)	162.00
2. Reduction in annual costs	
Pre-lamb crutching (1000 ewes x $0.55/ewe)	550.00
Less overdraft interest (1000 ewes x $0.21/ewe)[3]	210.00
Total advantages (A)	**$ 1436.27**
Disadvantages:	
3. Increase in annual costs	
Extra 40% crutching at weaning (1000 ewes x 0.40 x $0.15/ewe)	60.00
Increased post-shearing intake (1.5 kg for 15 days)	
(1000 ewes x 1.5 kg DM x $0.08/kg DM[4])	120.00
Total disadvantages (B)	**$ 180.00**
A-B (per 1000 ewes) =	**$ 1256.27**
Net return per ewe =	**$ 1.26/ewe**

1 The average wool price based on 15% P&B&C and 85% fleece.
2 Average fleeceweight at 8 months.
3 Refer to the cashflow analysis (Figure 6.2) for details.
4 The opportunity cost of feed (8c/kg DM) was based on potential earnings from a bull beef policy. The value of feed was calculated on a 20 % conversion efficiency, a 50 % dressing out percentage and a carcass value of $3.00 /kg .

Other Aspects

The partial budget shows an annual net financial advantage of $ 1.26/ewe (at 1993 costs and prices) for pre-lamb shearing (Table 6.2). As shown in Figure 6.1, the margin per ewe would have been larger in 1989, 1990, and 1992 because of the greater returns from early season wools in those years. However, there are other effects of a change to pre-lamb shearing, which do not occur annually in terms of income and expenditure or which do not have an easily quantified economic value, that need to be considered by farmers when they are evaluating a change in their shearing policy.

Spring to early summer cashflow is improved by pre-lamb shearing (See Figure 6.2.). A farmer would therefore have to arrange a smaller overdraft facility than with post-weaning shearing. In terms of transition management a change to pre-lamb shearing would provide an immediate benefit to cashflow, but other aspects of the change such as feed supplies and shelter would need to be planned in advance (see Chapter 1), particularly if the standard, rather than the cover, comb were to be used.

Pre-lamb shearing will improve the pattern of labour demand for farm staff by reducing the number of activities at the traditionally busy time of shearing/ weaning in November/ December. Some cost savings may be achieved by a change to pre-lamb shearing if casual labour is no longer required over the November-December period. Farmers believe that shorn ewes are easier to shift at lambing and docking and this could reduce labour inputs to these operations. From the shearing contractors' viewpoint a wider seasonal spread of work is provided if some farmers adopt pre-lamb ewe shearing. Thus, farmers would generally not have difficulty in arranging for shearers and shedhands for pre-lamb shearing. However getting sufficient fine weather to dry the sheep before shearing may be a problem in some districts.

There is some change in risk if pre-lamb shearing is adopted. As discussed previously, the potential for greater ewe losses and increased ewe feed intake in the immediate post-shearing period can be minimised by the use of cover combs and planned allocation of pasture and shelter (See Chapter 4).

In general wool quality (colour, strength, yield) is improved and wool faults are reduced by pre-lamb shearing (see Chapter 1, 4). These factors are important for realising wool price premiums over and above those associated with seasonal variation in supply as indicated by Figure 6.1.

An important management decision will be the timing of pre-lamb shearing relative to lambing. Shearing sheep 6 weeks or more prior to lambing, rather than 4 weeks as reported in this thesis, may increase the birthweight/ survival of lambs born to pre-lamb shorn ewes (see earlier discussion). However, pasture management is simplified if shearing is timed closer to lambing and the onset of spring pasture growth, because the quantity of feed reserves required is reduced. Once ewes have been pre-lamb shorn they may be able to exploit late spring pasture growth better than their post-wean shorn counterparts.

In summary, both the partial budget financial analysis and a consideration of other effects associated with pre-lamb shearing show that New Zealand sheep farmers currently not practising pre-lamb shearing should carefully consider this management option. A greater return for pre-lamb shearing ($ 1.26/ewe/year), simplified labour-management and an improved cashflow are major advantages of pre-lamb shearing. The major disadvantage of increased risk of cold stress and a feed shortage after pre-lamb shearing can be reduced by the use of cover combs (see Chapters 4 and 5) and long-term planning.

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APPENDIX I

Procedures for Washing Wool Samples and Calculating Clean Wool Growth Rate

1. After clipping, greasy midside wool samples were conditioned for at least 48 hours at 20 °C and 65% relative humidity (RH) and then weighed.

2. Each weighed greasy midside wool sample was placed in an individually labelled terylene mesh bag.

3. The bags containing the samples were placed in the four bowls (3 minutes per bowl) of a scouring machine and submerged sequentially, then the mechanical agitation turned on.

4. At the end of 3 minutes, the samples from each bowl were passed to the next bowl through squeeze rollers.

5. Bowls 1, 2 and 3 contained 32, 16 and 16 ml of the detergent teric GN9 in 36 litres of water at pH 8 and temperatures of 60, 55 and 50°C respectively, while bowl 4 contained cold water without detergent.

6. Following bowl 4, the samples were placed in a hydroextractor and spun for at least one minute. Then samples were spread evenly in a metal tray and placed in a forced draught at 82°C for about 6 minutes.

7. Dried samples were conditioned as described previously and then weighed.

8. The "growth rate of wool" was measured as the scoured (clean) weight of wool grown per square centimetre per day.

APPENDIX II

Pattern of Pasture Heights and Digestibility during Pregnancy and Lactation Periods (Experiment 2)

Figures AII.1 and AII.2 show the pattern of mean weekly HFRO sward stick green leaf contact heights and Ellinbank Pasture Meter (EPM) heights respectively of the pasture grazed by the May- and August-lambing ewes during the pre-lambing (P112-P140) and post-lambing (L0-L33) periods in Experiment 2. The pattern of mean weekly pasture heights during the period L40-L82 is also illustrated in Figure AII.3. Figures AII.1 and AII.2 indicate that the height of pasture over the pre-lambing period (P112-P140) was greater during the autumn than during the spring. Within each season, pasture height was greater during the pre-lambing period than during the post-lambing period, but was always maintained at or above 4 cm. Pasture height was generally greater for old pasture than for new pasture, particularly when height was measured by EPM. Figure AII.3 shows that the height of pasture during the period L40-L61 was greater during the autumn than during the spring, but this trend was reversed during the period L61-L82 and on average the height of pasture was similar for both policies.

Figures AII.4, AII.5 and AII.6 show the pattern of mean weekly DM, OM and DOM digestibility respectively of the pasture grazed by the May- and August-lambing ewes during the pre-lambing (P112-P141) and post-lambing (L8-L29) periods. The figures show that the herbage digestibility was considerably greater for new pasture than for old pasture during both the pre- and post-lambing periods.

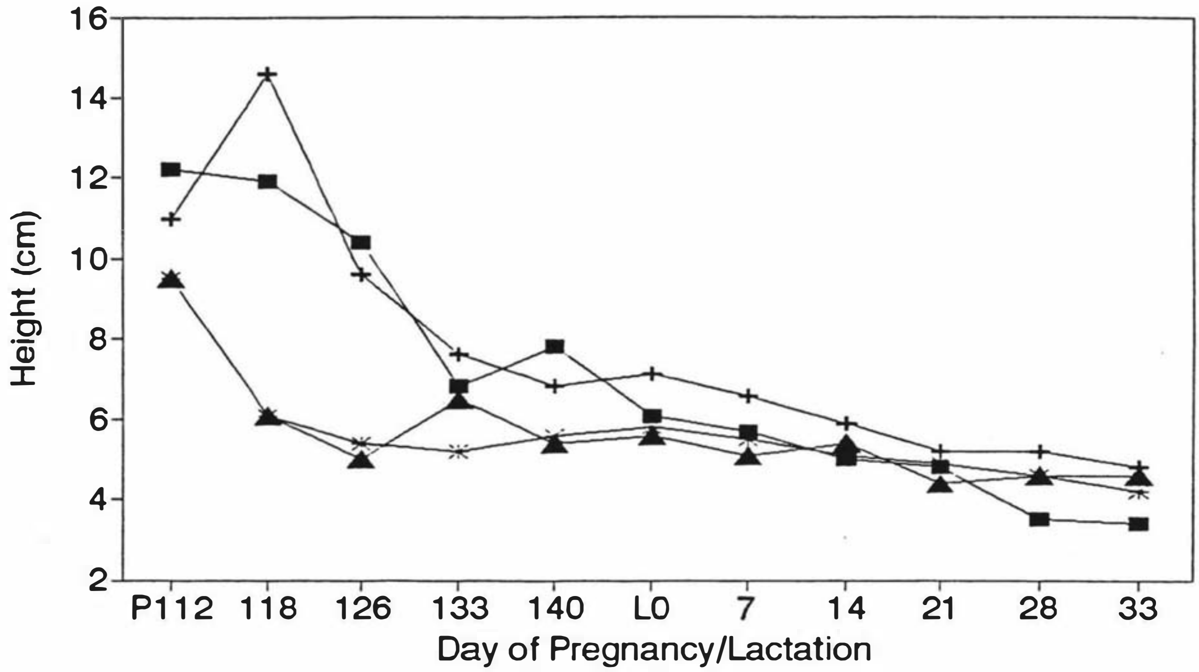

Figure AII.1 **Sward height, measured by the HFRO sward stick, over the period d112 of pregnancy (P112) to d33 of lactation (L33) in May- and August-lambing ewes. (■) May-lambing, new pasture, (+) May-lambing, old pasture, (*) August- lambing, new pasture, (▲) August-lambing, old pasture.**

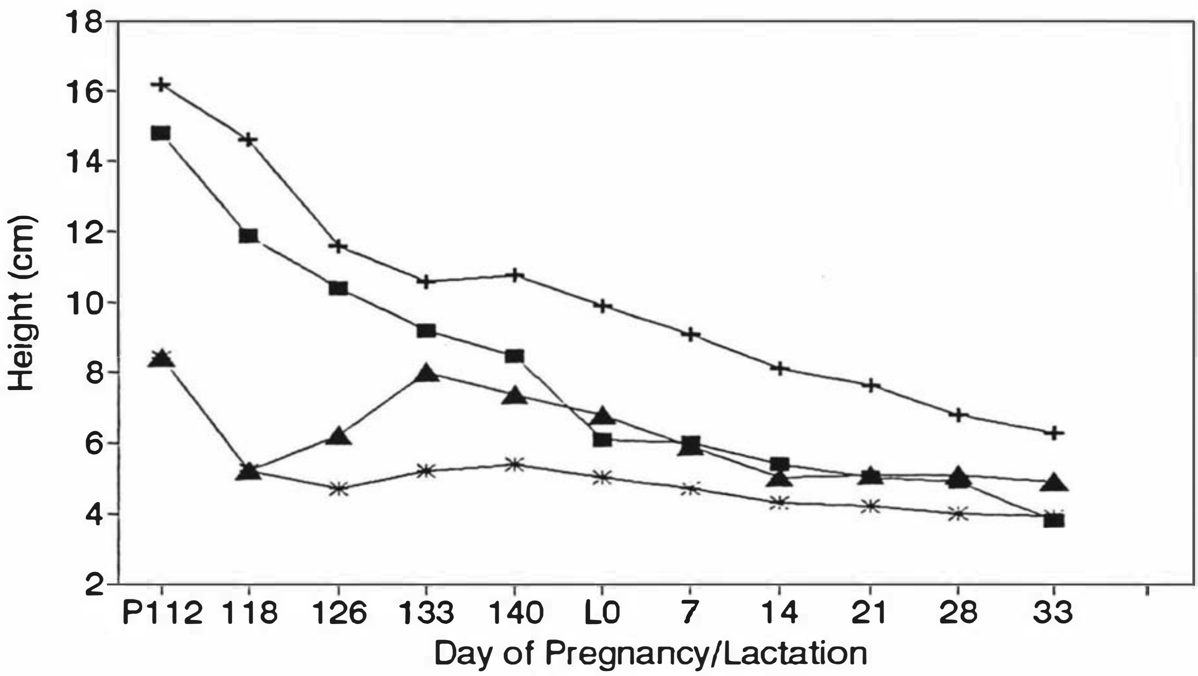

Figure AII.2 **Sward height, measured by the EPM, over the period d112 of pregnancy (P112) to d33 of lactation (L33) in May- and August-lambing ewes. (■) May-lambing, new pasture, (+) May-lambing, old pasture, (*) August-lambing, new pasture, (▲) August-lambing, old pasture.**

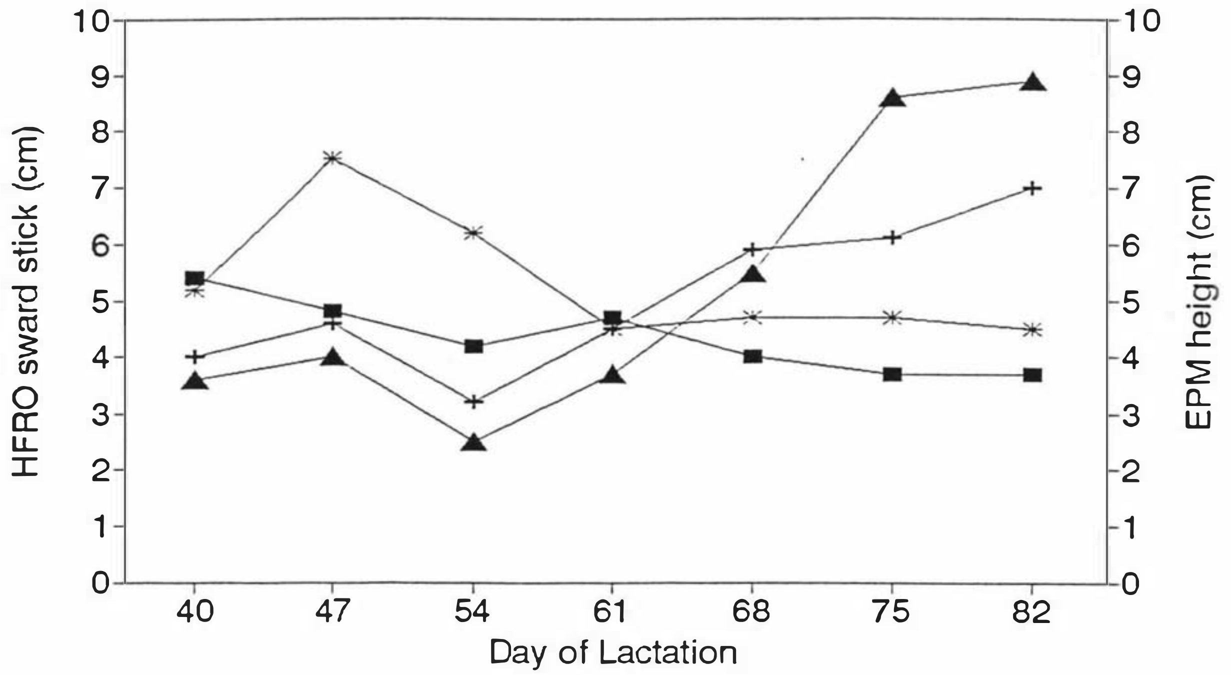

Figure AII.3 **Sward height, measured by both the HFRO sward stick and EPM, over the period d40-82 of lactation (L40-L82) in May- and August-lambing ewes. (■) May-lambing, HFRO, (*) May-lambing, EPM, (+) August-lambing, HFRO, (▲) August- lambing, EPM.**

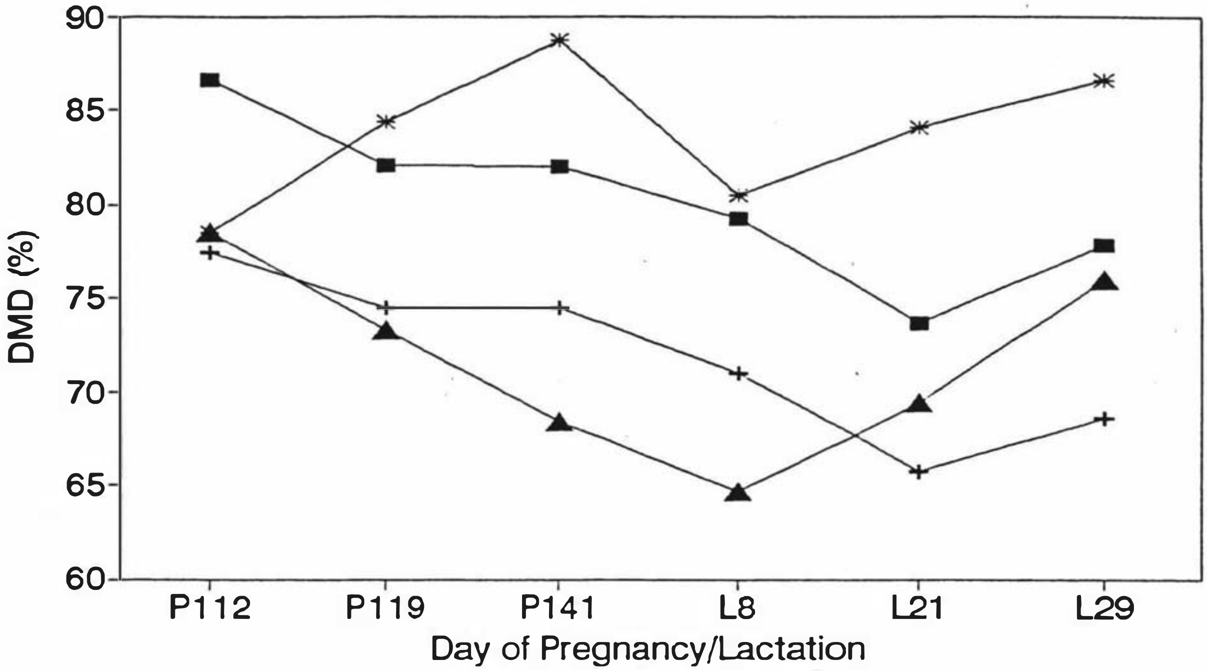

Figure AII.4 **Dry matter digestibility (DMD) of herbage grazed by May- and August-lambing ewes over the period d112 of pregnancy (P112) to d29 of lactation (L29). (■) May-lambing, new pasture, (+) May-lambing, old pasture, (*) August-lambing, new pasture, (▲) August-lambing, old pasture.**

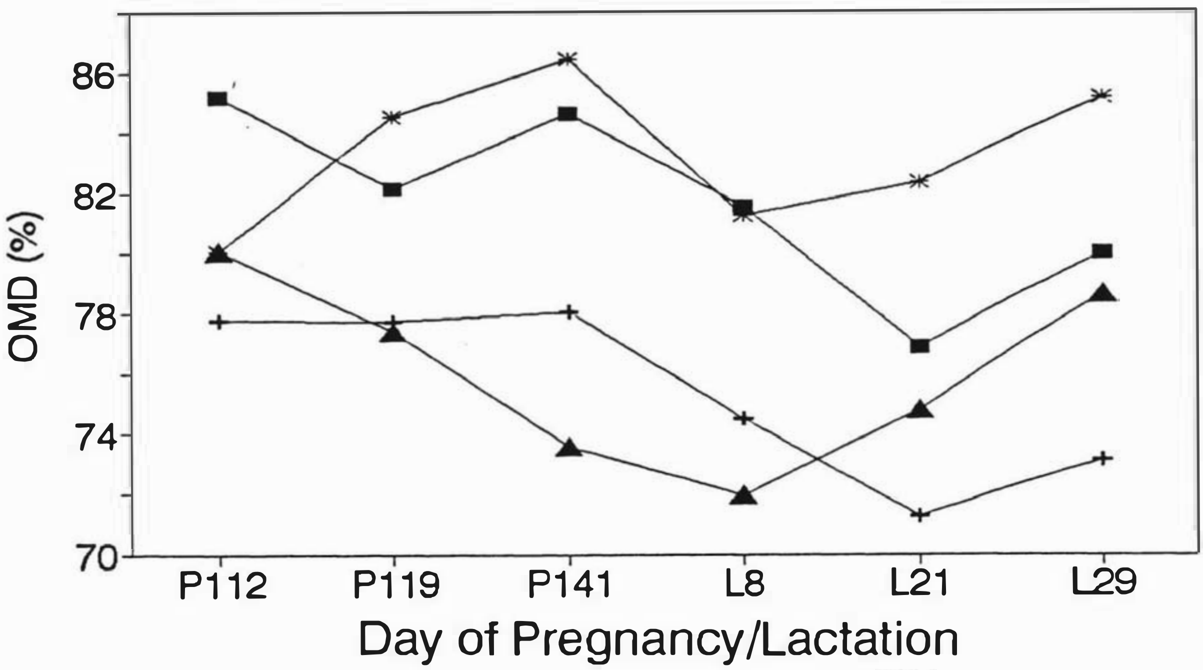

Figure AII.5 **Organic matter digestibility (OMD) of herbage grazed by May- and August-lambing ewes over the period d112 of pregnancy (P112) to d29 of lactation (L29). (■) May-lambing, new pasture, (+) May-lambing, old pasture, (*) August-lambing, new pasture, (▲) August-lambing, old pasture.**

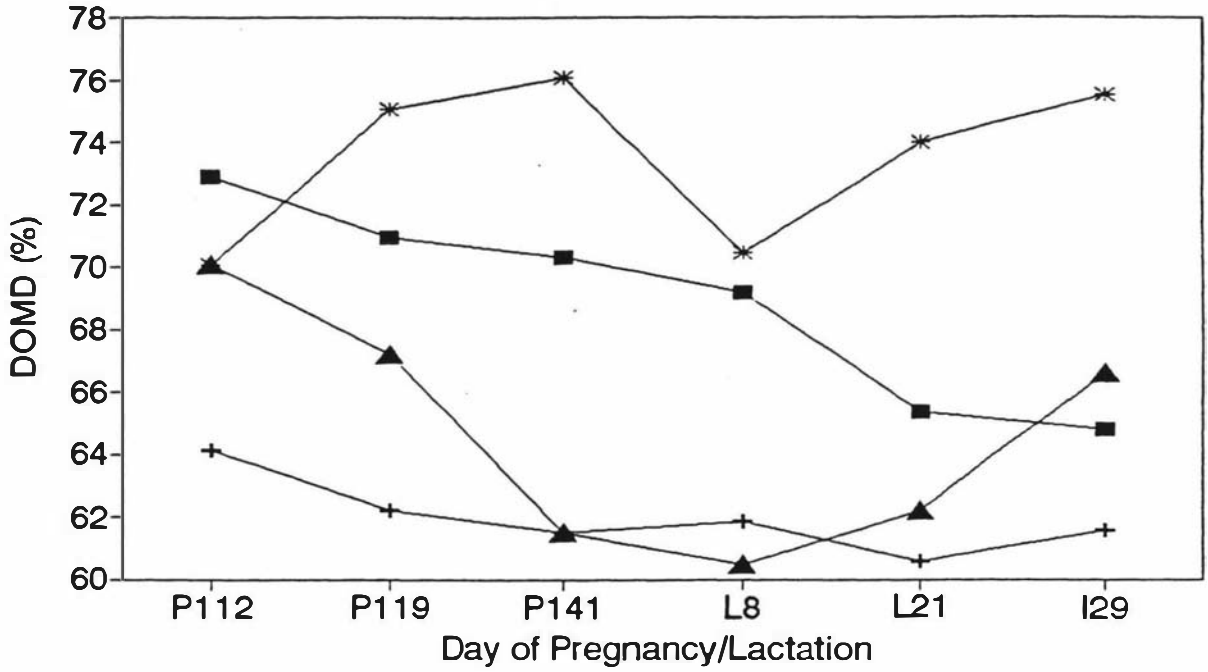

Figure AII.6 **Digestible organic matter in the dry matter (DOMD) of herbage grazed by May- and August-lambing ewes over the period d112 of pregnancy (P112) to d29 of lactation (L29). (■) May-lambing, new pasture, (+) May-lambing, old pasture, (*) August-lambing, new pasture, (▲) August-lambing, old pasture.**