A STUDY OF SOME FACTORS AFFECTING REPRODUCTION IN ONE- AND TWO-YEAR-OLD EWES

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ABSTRACT

Experiment I

Reproductive performance was investigated in 176 one-year-old Romney and Border Leicester x Romney (F1) ewes following joinings with entire or vasectomized rams in 1977. Two-year-old performance of these ewes was investigated in 1978. First service conception rate was 74.6% in 1977 and the regression on liveweight gain over joining was negative ($P < 0.01$). Overall, 81.4% of marked ewe lambs conceived with 80.3% of the lambs born surviving to weaning. Delaying weaning from 8 to 11 weeks of age resulted in small improvements in lamb growth but penalized ewe growth. Suckled ewe lambs were lighter at the two-year-old mating but weaned more lambs per ewe joined due to a large improvement in lamb survival. Fleece production was temporarily reduced. Commercial applications of early joining are discussed.

Experiment II

One hundred and nine 7 - 8 month old Romney ewe lambs and 108 adult Romney ewes were included in an ova transfer study to investigate age of ewe effects on ovum viability. Each of 48 ewe lambs received two 8 - 16 cell ova, one from a ewe lamb (homologous transfers) and one from an adult ewe. The source of ova were identifiable by birth coat colour markings of the lambs born. Ovum recovery and fertilization rates were high and similar in both ages of ewe. However, only 25% of ewe lamb ova were represented by lambs at term compared to 52.1% of adult ewe ova ($P < 0.01$). Possible causes of this difference are discussed.

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PREFACE

The investigation was conducted at 'Ripley Rise', a leasehold property of Massey University located west of the University's No. 4 Dairy Unit, and the Fertility Centre, part of the Department of Sheep Husbandry, Massey University. The experimental work was carried out from April 1977 to November 1978 and represents original research by the author under the supervision of Dr M.F. McDonald, Reader, Sheep Husbandry Department, Massey University.

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CHAPTER 1

INTRODUCTION

Several New Zealand studies have highlighted the low reproductive rate characteristic of the Romney breeding ewe. In some instances the application of animal breeding principles and improved management techniques have been demonstrated to overcome low levels of per head production. Border Leicester crossbreeding and large scale within breed selection programs have been utilised to rapidly improve lamb production. One significant aspect of improved management has been the adoption of replacement breeding ewe rearing systems that enhance subsequent production. Largely as a result of superior liveweight gains many immature ewes have the potential to be mated during the ewe lamb breeding season.

Considerable overseas information indicates that levels of reproductive performance attained by the ewe lamb are generally lower than expected from two-year-old ewes. Differences in reproduction between these age groups could arise from variations in the proportion of joined ewes mated, the numbers of ova shed, the number fertilized, the proportion of fertilized ova which develop to term and the extent of neonatal lamb mortality. In particular, recent studies have implicated a lower post-fertilization ovum survival rate of ewe lamb compared to mature ewe ova following transplantation techniques involving artificial oestrous synchronization.

New Zealand information on all aspects of reproduction in the immature ewe is limited. In particular, comparisons of Romney and Border Leicester x Romney (BLX) sheep have not included information on ewes lambing at one year of age.

The reasons advanced for the widespread reluctance of industry to adopt the practice of joining ewe lambs with entire rams include:

1. there is poor maternal performance at this early age;
2. progeny performance is unsatisfactory;
3. future productivity is jeopardized; and
4. management routine is interrupted.

The purpose of this investigation was to examine reproductive performance in contemporaneously born and reared one-year-old BLX and Romney ewes and its influence on two-year-old growth, wool production and various components of reproductive rate. Eight-month-old ewes were joined with entire or vasectomized rams. Ewes subsequently rearing lambs were weaned at one of two mean ages.

Studies were carried out on:

1. oestrous and ovarian activity;
2. lambing and weaning performance;
3. growth of ewes and lambs; and
4. wool production.

Furthermore, the technique of fertilized ovum transfer was utilized to compare the capacity of ova from naturally synchronized eight-month-old (homologously transferred) and mixed-age Romney ewes (heterologously transferred) to survive to term following transplantation into the reproductive tract of the puberal ewe. Studies were carried out on:

1. ewe lamb mating and insemination;
2. ovarian activity;
3. ovum fertilization and recovery; and
4. lamb production.

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

II.1 Introduction

It is commonly accepted that the production of more lambs per ewe lifetime can lead to increases in biological and economic efficiency. This can be achieved by increases in lambs born per lambing and lambings per lifetime. Successful reproduction in the immature ewe is one method of increasing the frequency of lambings.

Of approximately 13 million ewe lambs wintered annually in New Zealand (Anon, 1980) a small unknown proportion successfully complete reproduction. The returns claimed by implementing an early joining program (that is, the joining of ewe lambs to achieve parity at approximately twelve to fourteen months of age) include:

1. earlier fecundity progeny test of sires;
2. earlier fecundity performance test of ewes;
3. reduction in the generation interval and increases in numbers of lambs available for selection leading to greater rates of genetic gain;
4. improvements in two-year-old post-parturient maternal performance;
5. improvements in weight of lamb weaned per ewe lifetime and with reduced replacement ewe costs, an increased profitability per ewe lifetime; and
6. a more efficient utilization of seasonal feed supplies.

Ewe lamb barrenness in New Zealand in most likely a result of failure to be joined. If joined, inadequate sexual development prejudicing the attainment of first oestrus would limit successful reproduction in the majority of these ewe lambs. Failure to lamb following mating would account for the remaining barren ewe lambs. Dyrmundsson (1973) draws attention to the paucity of information on the incidence and causes of barrenness in mated ewe lambs. An understanding of those factors critical to the concomitant attainment of first oestrus and ovulation would be an important first step to increasing the likelihood of early joining. Knowledge of those factors important in successful conception as well as the relationship of ewe lamb performance to subsequent performance are critical to improving reproductive efficiency in the ewe.

II.2 Aspects of Puberty

II.2.1 Definition

Joubert (1963) highlights the inability of early investigators to formulate a universally acceptable definition of puberty. The various points of view concentrate on anatomical (Marshall, 1922), physiological (Asdell, 1946), behavioural (Crew, 1931) and maturational (Parkes, 1929) events in the female farm animal. Subsequent reports centre on aspects of gamete viability as being important considerations in defining puberty (Donovan and Van der Werff ten Bosch, 1965; Sadlier, 1969; Cupps et al., 1969). More recently the criterion of oestrus as evidence of the attainment of puberty in ewe lambs (Dyrmundsson, 1973) has been challenged. Edey et al., (1977, 1978) show that ovulation is not always a concomitant event of oestrus. Further, Edey et al., (1978) suggest that a more adequate definition of puberty must include the requirement to permit insemination at an ovulatory oestrus. However, while such a definition could have advantages where early joining is practiced, problems with measurement exist.

Although vaginal histological techniques can sometimes determine first oestrus and/or ovulation in the ewe (Radford and Watson, 1955; Robinson, 1959), the most common method for detecting oestrus involves rams equipped with crayoned harnesses (Radford et al., 1960). However, breed of ram differences in detection efficiency can limit the usefulness of this technique (Lees, 1971; Dyrmundsson and Lees, 1972a).

Laparotomy is commonly used to observe ovarian activity in sheep. More recently, many of the disadvantages associated with the technique (Oldham et al., 1976) have been overcome by the development of endoscopic procedures (Roberts, 1968; Kelly and Allison, 1976).

Vaginal swabbing enables collection of insemination and lambing information on the same ewe lamb (Allison et al., 1975; Chu and Edey, 1978). One disadvantage is that fertilization failure can be increased (Thibault, 1973).

The first appearance of crayon marks on the rumps of ewe lambs joined with harnessed rams appears to be an acceptable working definition of puberty in the ewe. However, for the purposes of the following discussions first ovulatory oestrus will be regarded as puberty.

Discussion of practical aspects of puberty often involves age, liveweight, ovulation rate, date and conception rate at this oestrus (Dyrmundsson, 1973).

II.2.2 Endocrinology

Increasingly more information is becoming available on endocrine events during foetal life through the first oestruses in ewe lambs.

. Foetal Pituitary Gonadotrophin

Luteinizing hormone (LH) has been detected in the anterior pituitary of foetal lambs (Mauleon and de Reviers, 1969); the increase in concentration from day 55 to 130 being independant of sex or twinning status (Foster et al., 1972a). A foetal steroid negative feedback mechanism has been postulated (Foster et al., 1972a).

The late foetal lamb pituitary can respond to exogenous gonadotrophic releasing hormone (GnRH) (Foster et al., 1972c). However, LH releasing factor activity is undetectable in foetal hypothalamic tissue (Foster et al., 1972e).

Thus, at least partial maturation of the hypothalamo-hypophyseal system is accomplished during intra-uterine life. Furthermore, high pituitary follicle stimulating hormone (FSH) levels throughout foetal life (Mauleon and de Revier, 1969) suggest separate control mechanisms for each gonadotrophin.

Foetal Serum Gonadotrophin

Foetal lamb serum LH levels are dependant on age of foetus (Foster et al., 1972a). A pre-parturient decline to very low levels is observed in both sexes (Foster et al., 1972a). Placental permeability studies discount the possibility that circulating foetal LH is of maternal origin (Foster et al., 1972b).

There appears to be no reports on ovine foetal serum FSH.

The relationship between pituitary and serum LH concentrations varies with age. In contrast to the increasing or plateaued pituitary levels characteristic of the final trimester of pregnancy, serum LH attains earlier maximal concentration then declines to very low levels near term (Foster et al., 1972a). These declining levels of foetal serum LH coincident with increasing maternal serum progesterone (Basset et al., 1969) and oestrogen (Challis, 1971) lead to the hypothesis (Foster et al., 1972a) of a maternal steroid-foetal hypothalamo-hypophyseal axis interaction on both LH synthesis and secretion. Although circulating progesterone (Linzell and Heap, 1968) and oestrogen (Findlay and Cox, 1970), and urinary (Kennedy et al., 1974) and gonadal (Mauleon et al., 1977) foetal lamb oestrogen have been detected, direct experimentation has yet to validate this hypothesis.

Neonatal Pituitary Gonadotrophin

The sex and twinning status dependant damping of pituitary LH concentration evident prior to birth persists through the first two to three weeks of life (Foster et al., 1972a,d) by which stage LH stores in females approach those of males. The relative inability of the two- compared to the ten-week-old lamb to release LH following stimulation with GnRH (Foster et al., 1972c) or oestrogen (Land et al., 1970; Foster and Karsch, 1975) adds congruency to the supposition that the pituitary may not have a reserve of LH available for release and may therefore be unable to respond to hypothalamic stimuli during early postnatal life. The ovary apparently promotes storage or stimulates synthesis of pituitary LH since oestrogen supplementation and/or ovariectomy decreases LH concentration (Leifer et al., 1972).

Little is known of neonatal pituitary FSH.

Neonatal Serum Gonadotrophin

The coincident transient damping of pituitary LH and serum gonadotrophin concentrations (Foster et al., 1972a,d; Leifer et al., 1972; Bindon, 1973; Bindon and Turner, 1974; Bindon et al., 1974; Foster et al., 1975a,b; Tassel et al., 1976; Fitzgerald and Butler, 1978) is followed by a postnatal serum LH rise (Foster et al., 1972a; 1975 a,b; Fitzgerald and Butler, 1978). Thimonier and Pelletier (1977) report a breed dependant decline. This elevation in mean circulating LH is characterized by surge peaks of increasing frequency and amplitude (Foster et al., 1975b). The discontinuous but rhythmic discharges resemble those of castrate rather than intact adult ewes (Foster et al., 1975b). Furthermore, these workers suggest that the pulsatile patterns of circulating LH reflect the tonic rather than surge mode of LH secretion.

Foster et al.,(1975a) postulate that the diminished levels of serum LH in neonatal female sheep reflect ovarian steroid negative feedback on the hypothalamo-hypophyseal system. The detection of oestradiol-17 α and β in the plasma of term foetuses (Findlay and Cox, 1970) and in the urine of the newborn (Kennedy et al., 1974) appear to be related to extensive follicular development at birth. However Kennedy et al., (1974) could not detect urinary oestrogens in four- and eight-week-old lambs, although Leifer et al., (1972) conclude that sufficient ovarian steroids are being synthesized and released prior to six weeks to affect uterine growth.

Ovariectomy at birth does not result in immediate serum gonadotrophin elevation indicating only partial maturation of the negative feedback mechanism (Foster et al., 1972d; Leifer et al., 1972; Foster et al., 1975b). Furthermore, when the rise occurs it is coincident with that found in intact female lambs (Foster et al., 1972d, 1975b). Further investigations are clearly necessary before the underlying mechanisms are elucidated.

The inhibition of LH release for up to six weeks following oestrogen administration in the newborn female lamb (Foster et al., 1971) invalidates the hypothalamo-hypophyseal refractoriness hypothesis. Alternatively, the brief lull in LH might be more related to other maturational events occurring within the hypothalamo-hypophyseal unit such as changes in GnRH or releasable pools of LH (Foster et al., 1975b).

The absence of any close relationship between preparturient maternal serum LH and the damping of gonadotrophic function in the late foetal-early neonate (bovine: Henricks et al., 1972; Edquist et al., 1973; guinea pig: Challis et al., 1971; man: de Hertogh et al., 1975) lead Levasseur (1977) to conclude that the damping process is independent of steroids. In addition, Tassel et al., (1976) were unable to show a relationship between ovarian concentrations of oestradiol-17β and age, follicular development or plasma gonadotrophins in the neonatal lamb.

The postnatal rise in serum (and pituitary) LH may follow release from the materno-placental steroid inhibition of the pituitary and indicate an ability of the neonatal ovary to produce steroids of sufficient quality or quantity to effect appreciable negative feedback on LH production (Foster et al., 1972a). The refractoriness of the day 20 ovary to exogenous gonadotrophin (Mauleon and de Reviers, 1969) or oestrogen (Foster and Karsch, 1975) supports this.

Foster et al., (1975a,b), Fitzgerald and Butler (1978) and Tassel et al., (1976) report low postpartum FSH levels in female lambs lasting six to eight weeks, although fecundity genotype differences appear important (Findlay and Bindon, 1976). Serum FSH levels then rise (Foster et al., 1975b) to peak twice between three and five months (Foster et al., 1975a; Fitzgerald and Butler, 1978).

Although experimentation on the mechanisms of FSH production and release are wanting, maturation of nervous system regulation of LH and FSH appears asynchronous (Dierschkle et al., 1974; Foster et al., 1975b).

First Oestruses

Serum LH concentrations are constant, although elevated compared to adult ewes, over the few weeks preceding first oestrus (Foster et al., 1975a; Echternkamp and Laster, 1976; Fitzgerald and Butler, 1978; Simaraks, 1978). This high baseline LH reflects the persistence of pulsatile release characterized by surge peaks of increasing frequency and amplitude (Foster et al., 1975a). Mean levels of circulating LH after first oestrus are not significantly different from those found prior to first oestrus (from about 11 weeks of age, Foster et al., 1975a). Furthermore, these workers report mean levels of LH five to seven fold higher for immature females than adults on day seven and fifteen of the oestrous cycle.

Peak circulating LH concentrations during episodic release are similar to those found prior to the onset of oestrus (Foster et al., 1975a). These same workers cite unpublished work which shows the magnitude and duration of elevated LH levels following pulsatile discharges to be less than those preceding the preovulatory surge. Also, the frequency of LH discharges during a six hour period prior to first oestrus are unpredictable but after puberal oestrus they appear related to the stage of the oestrous cycle and progesterone concentration; pulses being more frequent in the early- and late-luteal rather than the mid-luteal phase (Foster et al., 1975a).

In contrast, FSH levels remain within those found in the adult suggesting that negative feedback control of FSH secretion after the first few weeks of life does not alter appreciably with age (Foster et al., 1975a). This adds support to the supposition that the mechanisms controlling tonic LH secretion are different from those controlling tonic FSH secretion in developing female sheep (Foster et al., 1975b).

The onset of ovarian cyclicity does not appear to be associated with any marked change in negative feedback relationships between the hypothalamo-hypophyseal system and the ovaries (Foster et al., 1975b). Sex steroids appear to play no role in triggering this gonadotrophic function (Foster, 1974). Levasseur (1977) maintains that these steroids, whilst having a negative feedback effect on pituitary hormone secretion activities and variations in steroid sensitivity, are the result and not the cause of gonadotrophic function.

First ovulation may occur as a result of large ovarian sensitivity changes to high levels of episodic LH (Foster et al., 1975a). Alternatively, these authors suggest the onset of the surge mode of gonadotrophin secretion as the determinant for initiation of ovarian cyclicity. Further, since oestradiol can induce a LH surge early in life, (Foster and Karsch, 1975), the sustained release of LH observed shortly before first oestrus reflects activation of a competent surge mechanism by the positive feedback action of endogenous oestradiol.

Two recent studies implicate progesterone in the initiation of the preovulatory LH surge. Fitzgerald and Butler (1978) report a transient elevation of progesterone, lasting from one to four days, preceding the first true ovulatory increment in progesterone. Circulating LH patterns prior to this small rise are of similar magnitude and duration to the known ovulatory LH surge but occur six days earlier and lead to progesterone elevation within 12 hours compared to 48 hours following the prevovulatory surge (Ryan and Foster, 1978). It is postulated (Ryan and Foster, 1978) that at puberty the mechanism governing the LH surge is exquisitely responsive to the positive feedback of oestradiol such that the first LH surge is triggered by early increases in circulating oestradiol from the developing preovulatory follicle. Thus, premature ovulation or follicular luteinization would result in meagre progesterone production which, by acting on the LH surge mechanism, would delay the second LH surge until a later phase of oestradiol secretion, and therefore a more appropriate stage of follicular development for ovulation. Low serum progesterone in ewe lambs exhibiting anovular oestrus have been reported (Chu, 1977).

Studies of the central nervous system perception of the state of endocrinological development need to be undertaken to understand the initiation of gonadotrophic function and puberty.

II.3 Factors Affecting First Oestrus

The occurrence of first oestrus as well as age, liveweight and date at first oestrus in the immature ewe are influenced by many factors including genotype, nutrition, photoperoid and hormonal treatment. Studies of puberty reviewed by Dyrmundsson (1973) concentrated on the direct effects of these factors rather than the interdependencies between them (Land, 1978a,b). An understanding of these dependencies is critical to ensuring successful reproduction in the immature ewe.

II.3.1 Genotype

Genetic differences can contribute to variation between breeds, strains within breeds, sire groups, crossbred and inbred lines.

Lamb genotype has been shown to influence the proportion of ewe lambs exhibiting oestrus during their first breeding season (Hulet *et al.*, 1969; Foote *et al.*, 1970; Burfening *et al.*, 1971; Southam *et al.*, 1971; Dickerson and Laster, 1975; Walrave *et al.*, 1975; Baker *et al.*, 1978). Hulet *et al.*, (1969) showed important lamb genotype by year interactions implying a dependence of lamb genotype differences on environmental effects prevailing in a given year. Burfening *et al.*, (1971),however, failed to demonstrate this interaction although important lamb genotype by experiment interactions were noted.

Tierney (1976) reported an absence of first oestrus by ten months of age in several strains of low liveweight Merino lambs. However, by fifteen months of age not only were strain differences apparent but strain by year and strain by level of feeding interactions became important. Barlow and Hodges (1976) reported significant differences between strains of Merino ewe lambs in the incidence of first oestrus, especially early in the breeding season.

A higher proportion of Border Leicester-Romney crossbred, particularly F1 and F2, compared to straight-bred Romney ewe lambs showed first oestrus during the first but not the second half of the breeding season (Hight et al., 1973). Finn crossbreeding in particular can markedly increase the incidence of first oestrus (Southam et al., 1971; Laster et al., 1972;Dickerson and Laster, 1975; Quirke, 1978a; Meyer and French, 1979; Quirke and Gosling, 1979) although instances of only minor improvements have been reported (Cedillo et al., 1977; Quirke, 1979a). Meyer and French (1979) found little evidence for sire of lamb genotype by year interactions on the incidence of first oestrus.

Dam of lamb genotype has been reported to influence the proportion of cyclic ewe lambs (Dickerson and Laster, 1975; Cedillo et al., 1977) although sire genotype interactions can be important (Dickerson and Laster, 1975).

Genotypic factors can influence age at first oestrus although variation caused by environmental factors may tend to obscure these (Cupps et al., 1969). Lamb genotype differences can lead to variation in age at first oestrus (Hafez, 1953; Foote et al., 1970; Southam et al., 1971; Dickerson and Laster, 1975; Cumlivski, 1979). However, Baker et al., (1978) reported no effect. Year by genotype interactions can be important (Wiggins et al., 1970). Indirect evidence suggests some genetic variation in age at first oestrus among Romney ewe lambs (Ch'ang and Raeside, 1957; Ch'ang, 1968) but not within other genetic groups (Cedillo et al., 1977).

Several strains of Merino lambs have shown variation in age at first oestrus with higher fecundity strains tending to be younger (Tierney, 1969; Barlow and Hodges, 1976; Tierney, 1976).

Lang and Hight (1967) reported only minor differences in age at puberty of Romney and Border Leicester-Romney ewe lambs. Finn crossbreeding can reduce age at first oestrus (Southam et al., 1971; Dickerson and Laster, 1975; Quirke, 1978a, 1979a; Quirke and Gosling, 1979) although Cedillo et al., (1977) reported no effect.

Dam of lamb genotypic differences can result in differences in age at first oestrus (Dickerson and Laster, 1975; Cedillo et al., 1977).

Dyrmundsson's (1973) summary of the age at first oestrus in a number of breeds makes apparent the extremely wide variation between and within breeds.

Variation in weight at first oestrus for different ewe lamb genotypes is well known (Hafez, 1952, 1953; Foote et al., 1970; Southam et al., 1971; Hight et al., 1973; Dickerson and Laster, 1975). Finn crossbreeding with Rambouillet (Dickerson and Laster, 1975) Galway (Quirke, 1978a, 1979a; Quirke and Gosling, 1979), Targhee and Columbia (Southam et al., 1971) but not Romney (Meyer and French, 1979) ewes reduces weight at first oestrus. Although year effects are important in determining these weights, there is no interaction between breed and year (Quirke, 1978a).

Breed of dam differences in mean weight at puberty can be expected (Dickerson and Laster, 1975).

In view of the practical implications it is surprising that there seems to be few reports on genotypic variation in date of first oestrus (Dyrmundsson, 1973). Although lamb genotype is known to influence date of first oestrus (Hafez, 1952, 1953), the variation can be minimal (Foote et al., 1970). Crossbreeding, (Hight et al., 1973) especially with Finn genes (Meyer and French, 1979; Quirke, 1979a; Quirke and Gosling, 1979), can advance the date of first oestrus.

II.3.2 Liveweight and Growth

Many environmental effects on reproductive development in the ewe lamb are mediated through liveweight and liveweight change. Differential liveweight patterns can result

(i) directly as a consequence of nutritional treatments or

(ii) indirectly through, for example, birth date, birth-rearing rank, age of dam and year.

Direct Effects

Nutrition-induced joining liveweight differences in mature ewes have been studied primarily in relation to fertility and fecundity (Allen and Lamming, 1961a; Allden, 1970; Fletcher, 1974; Rattray et al., 1980). However, the role of nutrition in the attainment of reproductive function in immature ewes is initially important in relation to the attainment of first oestrus (Dyrmundsson, 1973). Sadlier (1969) points out that confounding exists between the effects of nutrition on growth and on the maturation of the reproductive system per se.

Improved rearing levels of nutrition promote the exhibition of first oestrus during the ewe lamb breeding season (Allen and Lamming, 1961b; McGuirk et al., 1968; Gunn, 1978; Moore et al., 1978; Younis et al., 1978; Nedkvitne, 1979) although incidence of oestrus differences between the various levels can be small (Southam et al., 1970; Keane, 1974c, 1975c; Al-Wahab and Bryant, 1978b; Quirke, 1979a; Quirke and Gosling, 1979).

Ch'ang (1958) reported a sudden unexpected onset of first oestrus in Romney ewe lambs following grazings of red clover, probably as a consequence of the oestrogenic properties of these plants.

Ewe lambs reared on high planes of nutrition are younger (Allen and Lamming, 1961b; Lamming, 1963; Southam _et al_., 1970; Keane, 1974c; Moore _et al_., 1978; Younis _et al_., 1978; Nedvitne, 1979; Quirke and Gosling, 1979), especially Finn crossbreds (Quirke, 1979a), and heavier (Allen and Lamming, 1961b; Southam _et al_., 1970; Keane, 1974c; Al-Wahab and Bryant, 1978b; Moore _et al_., 1978; Younis _et al_., 1978; Quirke and Gosling, 1979) at first oestrus than ewe lambs reared on lower planes of nutrition.

Indirect Effects

A high oestrous response in ewe lambs has been shown to be positively related to weaning (Hulet _et al_., 1969; Burfening _et al_., 1971; Hight _et al_., 1973; Dickerson and Laster, 1975), autumn (Ch'ang and Raeside, 1957; Lewis, 1959; Hulet _et al_., 1969; Hight _et al_., 1973; Baker _et al_., 1978), winter (Hight _et al_., 1973), and spring (Meyer and French, 1979) weights. Furthermore, high postweaning growth rates are reflected in a high oestrous response (Hafez, 1952; Burfening _et al_., 1971; Hight _et al_., 1973; Dickerson and Laster, 1975).

Later born (Ch'ang and Raeside, 1957; Burfening _et al_., 1971; Dickerson and Laster, 1975; Baker _et al_., 1978), twin-born and -reared (Ch'ang and Raeside, 1957; Burfening _et al_., 1971; Hight _et al_., 1973; Dickerson and Laster, 1975; Baker _et al_., 1978), and the progeny of one-year-old dams (McCall, 1980) are more likely to remain anoestrous as ewe lambs compared to earlier born, single-born and -reared, and the progeny of two year and older dams respectively. Keane (1975c) was unable to show an effect of age of lamb on oestrous activity when not associated with liveweight.

Lambs that are older at first oestrus also tend to have been lighter at weaning (Dyrmundsson and Lees, 1972a,d; Bichard et al., 1974; Dickerson and Laster, 1975; Quirke, 1978a) and in the autumn (Dyrmundsson and Lees, 1972a; Baker et al., 1978; Quirke, 1978a).

Later born lambs tend to be younger at first oestrus (Hafez, 1952; Sefidbakht et al., 1966; Hulet et al., 1969; Dyrmundsson and Lees, 1972a,d; Bichard et al., 1974; Dickerson and Laster, 1975; Cedillo et al., 1977; Baker et al., 1978; Quirke, 1978a; Younis et al., 1972). Twin-born lambs are often older than singles at first oestrus (Southam et al., 1971; Dyrmundsson and Lees, 1972a; Hight et al., 1973; Dickerson and Laster, 1975; Baker et al., 1978; Younis et al., 1978), particularly if late born (Dyrmundsson and Lees, 1972d).

Liveweight at first oestrus is positively related to weaning (Dyrmundsson and Lees, 1972a,b; Dickerson and Laster, 1975; Barlow and Hodges, 1976; Quirke, 1978a), autumn (Dyrmundsson and Lees, 1972a; Quirke, 1978a) and postweaning changes in liveweight (Hafez, 1952; Dickerson and Laster, 1975). These relationships probably explain the lighter weights at first oestrus for later (Hafez 1952; Dyrmundsson and Lees, 1972a,d; Dyrmundsson, 1978; Quirke, 1978a) and twin-born ewe lambs (Ch'ang and Rae, 1970; Dyrmundsson and Lees, 1972a; Hight et al., 1973; Dickerson and Laster, 1975; Quirke, 1978a).

While most reports indicate a positive association of age with liveweight at first oestrus (Dyrmundsson and Lees, 1972d; Cedillo et al., 1977; Dyrmundsson, 1978; Younis et al., 1978) this need not be so (Dyrmundsson and Lees, 1972d; Foster et al., 1975b).

Ewe lambs attain first oestrus earlier in the year if they are born earlier (Dyrmundsson and Lees, 1972d; Dyrmundsson, 1978; Quirke, 1978a), single-born (Dyrmundsson and Lees, 1972a) or heavier at weaning and in the autumn (Hight et al., 1973; Quirke, 1978a) as well as at the first oestrus (Hight et al., 1973; Keane, 1974c; Dyrmundsson, 1973). High pre-(Quirke,1978a) and post-weaning (Hight et al., 1973) liveweight gains also promote earlier dates of first oestrus.

Differences in growth patterns have been reported between cyclic and acyclic lambs (Hight et al., 1973). Furthermore, these workers found cyclic lambs to be older at weaning, especially if single-born, compared to their acyclic counterparts.

Faster growth during rearing will thus normally favour an earlier date of first oestrus at a lower age and heavier liveweight. In addition, ewe lambs reared under unfavourable conditions may fail to reach puberty.

II.3.3 Photoperiod

Photoperiodism is known to play a fundamental role in determining the seasonality of oestrous activity in the breeding ewe (Marshall, 1937; Yeates, 1949; Hafez, 1952). Very few studies have investigated the photoperiodic control of first oestrus in ewe lambs. Thus, while the cumulative photoperiod from birth to first oestrus can influence age at first oestrus (Watson and Gamble, 1961; Dyrmundsson and Lees, 1972a) confoundings of age, weight and season make for difficult interpretation.

Ewe lambs reared under constant photoperiod are still able to exhibit first oestrus within the normal age range (Radford, 1961; Smith, 1967). Furthermore, Al-Wahab and Bryant (1978b) reported a requirement for a decreasing photoperiod if cyclicity was to be maintained in younger, but not older, lambs that had been treated with exogenous hormones.

The precise role of photoperiod in initiating sexual function in the ewe lamb has yet to be determined. While the stimulus provided by decreasing photoperiod appears of importance in influencing the timing of first oestrus supportive experimental evidence is scarce (Ducker *et al.*, 1973).

II.3.4. Presence of the Ram

The unaccustomed presence of the ram with young and mature ewes prior to the natural onset of the breeding season may advance the date of first oestrus (Sinclair, 1950; Schinckel, 1954a,b; Edgar, 1965). The mechanism of this ram effect is unknown although odour and/or sound are sufficient stimuli (Watson and Radford, 1960) to induce responses.

An investigation of the ram effect in ewe lambs (Dyrmundsson and Lees, 1972b) indicates that while a high degree of oestrous synchronization can occur, the mean date at first oestrus is unaltered. Tervit *et al.*, (1977) report a similar phenomenon in ewes by varying the date of ram introduction.

Since timing of ram introduction, the use of entire or vasectomized rams (Edgar and Bilkey, 1963; Tervit *et al.*, 1977) and breed of ram (Tervit *et al.*, 1977) can modify the response in adult ewes, similar influences need evaluating with ewe lambs.

II.3.5 Exogenous Hormones

Sexual development and the attainment of puberty are under complex neural control involving the anterior pituitary and hypothalamic regions (Donovan and Van der Werff ten Bosch, 1965; Ganong and Krugt, 1969). Attempts to modify sexual development in immature ewes by exogenous hormone therapy can lead to a high degree of variability in the proportion of ewe lambs responding (Dyrmundsson, 1973).

Mansour (1959), Denamur and Mauleon (1963), Land and McGovern (1968), Goerke and Dutt (1975), and Mellin et al., (1975) have successfully induced ovulation with gonadotrophin. Responses are improved following progesterone priming (Thimonier et al., 1968; Rierra et al., 1970; Burfening and Van Horn, 1970). Mansour (1959) found that progesterone pretreatment also reduces the age at which gonadotrophin can induce ovulation and postulates the absence of a factor concerned with ovulation in the immature lamb pituitary as a major cause of ovarian refractoriness following treatment.

Mellin et al., (1975) found that pregant mares' serum gonadotrophin (P.M.S.G.) priming improves ovarian responses to GnRH. Intravaginal progesterone-impregnanted sponge therapy prior to P.M.S.G. gives excellent oestrous induction and synchronization although some oestrous lambs fail to ovulate (Keane, 1975a,b). Early indications that oestrogen could induce precocious first oestrus in ewe lambs was provided by Ch'ang (1958) who reported that Romney ewe lambs grazing oestrogenic red clovers after weaning were oestrous much earlier in the breeding season than was expected.

Improved oestrous responses have been reported in older lambs following progesterone and P.M.S.G. therapy with (Sefidbakht et al., 1967; Foote and Bennett, 1968) and without oestrogen (Keane, 1974a, 1975a; Al-Wahab and Bryant, 1978a,b).

In general, treatment times close to the natural breeding season with progesterone (Ch'ang et al., 1968, Quirke and Hanrahan, 1977), P.M.S.G. (Allen and Lamming, 1961b) or both (Keane, 1974a; Al-Wahab and Bryant, 1978a; Quirke, 1978b) result in an excellent oestrous response. Such responses may vary with breed (Quirke, 1978b) but are relatively insensitive to liveweight (Gordon, 1967a; Keane, 1974c).

II.4 Reproductive Behaviour

Many of the factors influencing the occurrence of first oestrus also influence the number of oestruses, duration of each oestrus, interval between successive oestruses and level of ovarian follicular activity.

II.4.1 Duration of the First Breeding Season

The number of days between the first and the last oestrus is commonly accepted to be a measure of the duration of the breeding season of an individual sheep. Alternatively, it can be estimated by the number of oestruses, although accuracy is poor if oestrous cycle lengths are variable.

It is widely recognized that the ewe lamb breeding season is shorter and more variable than is common in older ewes. This is due to the later commencement and earlier cessation of oestrous behaviour (McKenzie and Terrill, 1937; Hafez, 1951, 1952; Watson and Gamble, 1961; Wiggins et al., 1970; Hight et al., 1973; Quirke, 1978a). Icelandic ewe lambs, for example, experience half as many oestruses as mature ewes of the same breed (Dyrmundsson, 1978).

Furthermore, while the midpoint of the breeding season in mature ewes can occur about the shortest day (Hafez, 1952; Averill, 1959) this may (Hammond, 1944; Dyrmundsson and Lees, 1972a) or may not (Hafez, 1952; Ch'ang and Raeside, 1957; Hight et al., 1973; Dyrmundsson, 1978) be so for ewe lambs. The latitude from which breeds originated may be an important cause of variation in mean date of the ewe lamb sexual season (Hafez, 1953; Mounib et al., 1956).

The longer breeding season for summer- and winter- compared to spring-born Merino lambs highlights the season of birth effects (Watson and Gamble, 1961). Within a season (spring) earlier born ewe lambs tend to experience a longer first breeding season than those born later (Hafez, 1952; Ch'ang and Raeside, 1957, Ch'ang and Rae, 1970; Dyrmundsson and Lees, 1972a; Hight et al., 1973; Quirke, 1978a). Furthermore, ewe lambs attaining puberty early in the breeding season tend to experience a longer breeding season (Dyrmundsson and Lees, 1972a; Bichard et al., 1974). However, this may not be so in autumn-born lambs (Wiggins et al., 1970).

Genetic variation in number of oestruses is evidenced by moderate heritability estimates (Ch'ang and Rae, 1970; Baker et al., 1979). Breed and crossbreed of lamb are important (Hafez, 1952; Joubert, 1963; Foote et al., 1970; Hight et al., 1973), especially Finn genotypes (Quirke, 1978a; Meyer and French, 1979).

Higher levels of rearing nutrition promote a longer first breeding season (McGuirk et al., 1968; Burfening et al., 1971; Moore et al., 1978; Younis et al., 1978; Quirke and Gosling, 1979). A positive relationship exists between weight at weaning and in the autumn (Hight et al., 1973; Quirke, 1978a), and number of oestruses. It is likely that age of dam (Ch'ang and Rae, 1970), type of birth-rearing rank, age (Ch'ang and Rae, 1970; Dyrmundsson and Lees, 1972a; Hight et al., 1973) and to a lesser extent year (Ch'ang and Rae, 1970; Foote et al., 1970; Quirke, 1978a) effects on duration of the breeding season act through liveweight.

II.4.2 Oestrous Behaviour

The detailed mating behaviour of ewe lambs during the first breeding season has received little attention.

While it is widely recognized that ewe lambs remain oestrous for a shorter duration than young or mature ewes (McKenzie and Phillips, 1930; Hafez, 1952; Lambourne, 1956; Wiggins et al., 1970; Hanrahan and Quirke, 1975; Dyrmundsson, 1978), the physiological basis for this difference is unclear. Lindsay (1966) suggested oestrogen insufficiency as a possible factor. Smith et al., (1976) failed to substantiate this and suggested, since oestrous behaviour depends on the accumulation and action of oestradiol-17β on specific hypothalamic centres (Clegg et al., 1958; Clegg and Ganong, 1960; Radford, 1967), a low affinity or concentration of these hypothalamic receptor sites in ewe lambs. Nonetheless, Whyman (1978) demonstrates a dependence of oestrus duration on exogenous oestrogen in prepuberal ewe lambs.

Evidence for a large genetic component as a cause of variation in oestrus duration is limited (Hanrahan and Quirke, 1975). Ewe lambs of the high fecundity Finn breed remain oestrous longer than expected (Land, 1970; Osborne, 1970). While longer oestruses are significantly correlated to litter size in mature ewes of this genotype, the relationship is weak for immature ewes (Land, 1970).

Ewe lambs experiencing anovular first oestrus remain receptive to the ram longer (Edey et al., 1977,1978) whereas lambs anovular at a subsequent oestrus experience a shorter oestrus than ewe lambs ovulating at oestrus (Edey et al., 1977).

The number of previous oestruses, except in the case of Finn and Finn Dorset lambs (Hanrahan and Quirke, 1975), has little influence on the mean duration of oestrus (Gurzav, 1970; Edey et al., 1978).

The low intensity of oestrus, assessed by willingness to mate (Hafez, 1951, 1952; Hafez and Scott, 1962; Anderson, 1969; West et al., 1973; Keane, 1974c; Edey et al., 1978), probably explains the low incidence of multiple sire marking and the positive relationship between marking grade and conception in ewe lambs (Allison et al., 1975).

Oestrus intensity is relatively insensitive to number of previous oestruses and ability to ovulate at oestrus (Edey et al., 1978).

II.4.3 Inter-oestrus Interval

The duration of the oestrous cycle in the ewe ranges from fourteen to nineteen days although extended cycles resulting from ovulation without oestrus can occasionally occur (Hafez, 1974). Ewe lambs experience more irregular intervals between successive oestruses (Hafez, 1952; Dyrmundsson and Lees, 1972a; Dyrmundsson, 1973; Dyrmundsson, 1978) although ovulation can be more regular (Cleverdon 1980). Thus the term oestrous cycle is considered inappropriate for this age group.

Foote et al., (1970) found a reduction in the interval at the beginning of the breeding season. Dyrmundsson (1978), however, reports consistent intervals over the first breeding season in Icelandic ewe lambs.

Evidence for genotypic differences in mean inter-oestrus intervals is unconvincing (Foote et al., 1970; Quirke, 1978a) although Edey et al., (1977) suggest that breed and age of lamb are important.

Ewe lambs anovular at oestrus return significantly earlier to oestrus (Edey et al., 1977) suggesting progesterone insufficiency as a possible cause. Although photoperiod appears of minor significance (Radford, 1961), high levels of nutrition tend to reduce inter-oestrus intervals (Lamming, 1963).

Extended breeding seasons are more common if inter-oestrus intervals are regular (Sefidbakht et al., 1966; Hulet et al., 1969; Dyrmundsson and Lees, 1972a).

II.4.4 Ovarian Activity

The evaluation of factors affecting the variability of ewe lamb ovulation rates is hindered by low multiple ovulation rates characteristic of this age group (Dyrmundsson, 1973).

Stage of the breeding season, unlike the situation in mature ewes (McDonald and Ch'ang 1966; Bradford, 1972; Kelly et al., 1976), has little influence on ewe lamb ovulation rate (Edey et al., 1978; Williams et al., 1978). However, recent results with high ovulation rate lambs have shown a decline, particularly in high plane of nutrition groups (Cleverdon, 1980).

While ewes are responsive to nutritionally-induced liveweight differences (Cumming, 1977; Allison and Kelly, 1978; Morley et al., 1978; Smith et al., 1979; Rattray et al., 1980) the relative unresponsiveness of the ewe lamb (Allen and Lamming, 1961b; Southam et al., 1971; Keane, 1975c; Quirke and Gosling, 1979) suggests differences between nutritional (and therefore liveweight) effects on ovulation rate in ewes at or near mature weights and ewe lambs in the growth phase at far from mature weights. However, Cleverdon (1980) has reported a positive effect in several genotypes prior to one year of age.

Genetic variation exists between (Bradford, 1972; Wheeler and Land, 1977; Kelly et al., 1976; Land et al., 1979) and within (Packham and Triffit, 1966; Bindon et al., 1971; Trounson and Moore, 1972) breeds for mature ewes and ewe lambs (Southam et al., 1971; Hight et al., 1973; Echternkampand Laster, 1976; Hight and Jury, 1976; Quirke, 1978b; Meyer and French, 1979; Quirke and Gosling, 1979). Differences in early plasma gonadotrophin levels do not explain differences in ewe lamb ovulation rate between breeds (Ekternkamp and Laster, 1976).

Land (1977) reports correlated ewe lamb ovulation rate responses in selection lines based on ram testicular size suggesting common physiological pathways.

Hight *et al.*, (1973) report a higher incidence of multiple ovulations in single-compared to twin-born lambs.

Ch'ang *et al.*, (1968) failed to increase ovulation rate in progestagen-only treated ewe lambs near the beginning of the breeding season. However, the inclusion of a gonadotrophin treatment can result in significant increases (Allen and Lamming, 1961b; Keane, 1974a; Quirke, 1978b). Furthermore, the response appears dose dependent (Keane, 1975e; Quirke, 1979b).

Gurzav (1970) reports a lower interval from onset of oestrus to ovulation in ewe lambs than is commonly reported for mature ewes (Whyman *et al.*, 1979). However, both studies report similar intervals between ovulation and the cessation of oestrus for the two age groups.

Silent heat (that is, anoestrous ovulation) has been reported in immature ewes (Foote *et al.*, 1970; Keane, 1974c; Simaraks, 1978; Quirke, 1979d). Ovulation rate is often similar at silent and first oestrus (Sefidbakht *et al.*, 1966; Foote *et al.*, 1970). However, Cleverdon (1980) reports an increase in ovulation rate in four of six genotypes studied. Cleverdon (1980) reports that 18%, 56% and 26% of lambs (N=320) experience none, one, or more than one silent heat, respectively. Furthermore, almost half of the ewe lambs in her study (48%) exhibited at least one post-season silent heat. Sefidbakht (1969) has also reported this phenomenon in immature ewes.

Low growth rate is suggested as a major cause influencing the incidence of prebreeding season silent heat (Hafez, 1952). However, Cleverdon (1980) reports small nutritional effects: 78% of high plane and 86% of low plane lambs experiencing at least one. Year of birth effects appear small (Sefidbakht, 1969). Of more importance are season of birth (Keane, 1975c), stage of breeding season (Keane, 1974a), age at first oestrus (Chu and Edey, 1978) and genotype (Cleverdon, 1980).

The significance of silent heats is uncertain. Foote et al., (1970) suggest that conditioning by progesterone, or some other influence of the corpus luteum, is a requirement for first oestrus. However, silent heat is not a prerequisite for first oestrus (Edey et al., 1977).

Silent heat may arise as a consequence of the higher oestrogen threshold for oestrus than ovulation (Waite and Foote, 1962). Chu and Edey (1978) provide evidence of strong oestrogenic influences in lambs some 13 to 19 days prior to first oestrus. It is not clear whether this is related to the silent heat phenomenon.

Follicle numbers increase over the first few weeks of postnatal life then decline to remain low until near first oestrus (Kennedy et al., 1974). During the weeks preceding puberty variation in follicle size and number appear erratic (Chu and Edey, 1978). However, fewer are apparent a few days after puberty (Chu and Edey, 1978).

Nutrition can influence the size and number of ovarian follicles (Phillips et al., 1945; Allen and Lamming, 1961b). In particular the ingestion of oestrogenic clovers can lead to precocious graffian follicle development (Ch'ang 1958).

None of the parameters studied by Tassel et al., (1976) were able to adequately describe the endocrinology of follicle development in the ewe lamb.

While relationships may exist between follicular development and ovulation rate in mature ewes (Turnbull et al., 1977), it is not known whether such relationships exist in immature ewes.

In summary, ovarian activity in immature ewes can be erratic with ovulation occuring without oestrus. Ovulation rates are generally lower than in young and mature ewes and appear less sensitive to environmental influences.

II.5 Early Reproductive Performance

A high proportion of pregnant ewe lambs is an important component of ewe lamb reproductive efficiency. Wide variation between and within breeds is apparent (tabulated by Dyrmundsson, 1973). Most studies indicate a lower efficiency in immature compared to mature ewes (Williams, 1954; Yalcin and Bichard, 1964; Donald and Read, 1967; Southam et al., 1971; Laster et al., 1972; Keane, 1974c; Land et al., 1974; Tyrell, 1976; Baker et al., 1978; Levine et al., 1978).

II.5.1 Incidence of Oestrus

Factors influencing the proportion of ewe lambs displaying first oestrus have been discussed (Chapter II.3). The proportion of lambs displaying oestrus during the entire first breeding season represents the potential mating population. In practice the proportion actually mated is lower. This arises because the ewe lamb mating season, that period during which entire rams are joined, extends over a limited part of the breeding season. In addition, the further apart the midpoints of the mating and breeding seasons, the lower the expected proportion mated.

Failure to display oestrus over the mating period can be a major cause of low ewe lamb reproductive efficiency (Godlee, 1968a,b; McGuirk et al., 1968; Allison et al., 1975; Barlow and Hodges, 1976; Tyrell, 1976; Quirke, 1978b).

II.5.2 Conception

The ability to conceive following mating at a single oestrus (measured by first service conception rate) is important in determining high ewe lamb pregnancy rates, especially with restricted mating seasons. Sources of reproductive wastage include: insemination failure, post-insemination fertilization failure, failure to ovulate, and post-fertilization embryonic loss.

Important aspects of ewe lamb courtship are discussed by Edey et al., (1978). Failure to be inseminated is largely a consequence of the inferior mating behaviour characteristic of most oestrous lambs.

Allison et al., (1975) report few ewe lambs mated by more than one of several available rams, inspite of ram ratios (number of rams per ewe lamb joined) in excess of mature ewe requirements (Allison, 1975). More importantly, insemination failure rate (lambs unsuccessfully inseminated per lamb marked) decreases as the number of rams marking each lamb increases (Allison et al., 1975; Chu and Edey, 1978). Well grown lambs may be more successfully inseminated during courtship (Edey et al., 1978).

Anovular oestrus can contribute to low conception rates. However, the incidence is very low in well grown lambs (Edey et al., 1978).

There is a paucity of information in the literature on ova fertilization rates in the immature ewe. Furthermore, no information is available on post-insemination fertilization failure in immature ewes. Allen and Lamming (1961b) indicate that high rates are achieved in immature ewes and, furthermore, weight differences at mating appear unimportant. Fertilization rates achieved in lambs and eighteen month ewes are similar at both the first and third oestrus of the breeding season (Williams *et al.*, 1978).

Fertilization rate following progestagen-PMSG treatment during the ewe lamb breeding season is high (Bradford *et al.*, 1971), does not vary significantly with ovulation rate (Quirke, 1979a) and can be similar to that reported for adult ewes (Hanrahan and Quirke, 1975).

The incidence and causes of embryonic mortality in ewes is relatively well documented (Edey 1976). However, significantly less is known regarding such losses in the immature ewe (Dyrmundsson, 1973). Quirke (1979a) estimates embryonic mortality rate (proportion of fertilized ova not represented by viable embryos) at thirty days *post-coitum* to be two to threefold that occurring in mature ewes (Edey, 1969). Conditions within the ewe lamb and adult ewe uteri appear equally favourable for multiple embryo development (Quirke, 1979b,d). Furthermore, Quirke and Hanrahan (1977) indicate a lower potential of fertilized ova from ewe lambs to develop to term compared to ova from mature ewes. It is clear, therefore, that adverse conditions in the reproductive tract during ovum transport and/or cleavage or factors inherent in the ova of ewe lambs contribute to this reduced post-fertilization survival rate.

Increases in ovulation rate associated with super-ovulation treatments are often not reflected in any increase in litter size (lambs born per ewe lambing) (Keane, 1974a; Quirke, 1978b) indicating high levels of ovum wastage at higher ovulation rates.

Ovum survival rates for ewe lambs returning to service are lower than for first service lambs (Edey *et al.*, 1978). Fertilization failure or early embryonic mortality are likely to be the causes (Edey *et al.*, 1975) since cycle lengths between first and subsequent oestrus are within the normal range (15-19 days).

Bichard et al., (1974) attribute increases in lambing rate (ewe lambs lambing per ewe lamb joined) following supplementation and/or housing to reductions in embryo deaths. However, more information is necessary before nutrition-embryo survival relationships in ewe lambs are clearly understood.

Some results suggest that pregnancy rate (ewe lambs lambing per ewe lamb marked) is higher in ewe lambs of lower mating weights (McGuirk et al., 1968; Keane, 1974c).

Pre-mating shearing consistently improves pregnancy rate in ewe lambs of several breeds (Gordon, 1967b; Nedkvitne, 1979).

The ratio of ewe lambs lambing per ewe lamb present at lambing is markedly inferior if ewe lambs are born to one-year-old rather than older dams, and if twin- rather than single-born and reared by one-year-old dams (McCall, 1980). Low fertility in ewe lambs appears to be a general phenomena which can be attributed in part to a high prenatal embryo loss, although the uterine environment is considered to be favourable for embryonic development.

II.5.3 Progeny Survival

A major problem associated with breeding from ewe lambs is the relatively high perinatal loss in their offspring compared to offspring of older ewes (Williams, 1954; Donald and Read, 1967; Dyrmundsson, 1973; Tyrell, 1974; Baker et al., 1978; McCall, 1980). The causes of differences in mortality are not well established.

The relationship between lamb birthweight and survival is well established for progeny of mature ewes (Hight and Jury, 1970). Similar relationships exist for ewe lamb progeny (Gordon, 1967b). However, birthweights of ewe lamb progeny are generally lower and therefore lamb viability is often reduced compared to progeny born to older dams (Hafez, 1953; Donald and Read, 1967; Canon and Bath, 1969;

Robinson *et al.*, 1971; Southam *et al.*, 1971; Dyrmundsson, 1973). In addition, at the same birthweight the incidence of mortality tends to be greater in lambs born to immature rather than older ewes (Gordon, 1967b). The shorter duration of gestation (Lewis, 1959; Gordon, 1967b; Southam *et al.*, 1971; Dyrmundsson, 1973; Quirke *et al.*, 1978; Younis *et al.*, 1978) and a higher incidence of dystokia (Lewis, 1959; Godlee and Scarlett, 1968) may partially explain this. The low birth weights of twins born to immature ewes probably explains the extremely high mortality of these lambs (Lewis, 1959; Gordon, 1967b).

A larger majority of ewe lamb offspring deaths occur within twenty four hours of birth compared to offspring of mature ewes (Gordon, 1967b).

Keane (1975d) suggests the delayed onset of lactation as a contributing factor to high ewe lamb offspring mortality. Mothering ability does not appear a likely cause (Apps, 1953; Lewis, 1959; Mair, 1963; Godlee, 1968b; Dyrmundsson, 1973).

Offspring survival rate of ewe lambs born to one year dams is inferior to offspring of ewe lambs born to older dams (McCall, 1980).

II.5.4 Milk Production and Progeny Growth

The importance of milk in the diet of the lamb and factors affecting milk yield in adult ewes have been reviewed (Glover, 1972). Similar relationships are likely to exist in immature ewes and their offspring, although little is documented (Dyrmundsson, 1973).

Keane (1975d) concludes that milk intake and growth rate of single lambs reared by one-year-old dams and twin lambs reared by older dams, are similar. Other findings support this (Lewis, 1959; Mair, 1963; Yalcin and Bichard, 1964; Canon and Bath, 1969; Baker *et al.*, 1978).

McCall (1980) reports a carry-over effect of age of maternal grandam on weaning and spring weights of lambs born to one-year-old dams.

In view of the economic and practical advantages often advanced in favour of early weaning, it is surprising that nothing appears to have been published for one-year-old dams and offspring. In older ewes, weaning onto ryegrass-white clover pasture (Rattray et al., 1976) or lucurne (Jagusch et al., 1970; Rattray et al., 1976) as early as four weeks has little effect on weight of lambs at twelve weeks of age. In particular, twin lambs reared by older dams perform satisfactorily when weaned at a young age (Jagusch et al., 1970).

II.6 Progeny Performance

Production level differences between breeding ewes born to one year compared to older dams are largely undocumented. In New Zealand, progeny born to one-year-old dams are usually destined for export lamb meat production. However, the Waihora Romney group breeding scheme consistently retains such progeny for breeding purposes (Hight et al., 1975). Such females have consistently lighter weaning and spring liveweight as well as fifteen month fleece weight compared to progeny born to older dams (McCall, 1980). Furthermore, ewe lamb weaning rate (lambs weaned per ewe lamb present at mating) is markedly inferior largely as a result of a low lambing rate (ewe lambs lambing per ewe lamb present at lambing). The sigmoid relationship between one year liveweight and ewe lamb lambing rate suggests that ewe lambs born to one-year-old dams are more responsive to increases in prelambing liveweight than ewe lambs born to older dams (McCall, 1980).

II.7 Early Reproduction and Subsequent Production

Mating of ewes to lamb at about one year of age is not widely practiced. The majority of ewes are mated first at two years of age. However, early joining is common and increasing under improved management systems (Williams, 1954; Steine, 1979). In New Zealand, the practice would be expected to increase in frequency provided levels of early and subsequent performance are satisfactory.

II.7.1 Maternal Performance

Growth and Development

It is well established that lamb production from immature ewes may check their growth and development at this early stage, even if only temporarily (Spencer et al., 1942; Canon and Bath, 1969; Keane, 1974b; Tyrell et al., 1974; Baker et al., 1978). Liveweight differences arising from differential first winter nutrition often persist into adult life (Bradford et al., 1961; Purser and Roberts, 1964; Reardon and Lambourne, 1966). However, eighteen month prejoining liveweight differences between previously parous and barren ewe lambs are slight or neglible and rarely persist into later years (Briggs, 1936; Mair, 1963; Williams, 1954; Tyrell, 1976; Southam et al., 1971).

Palsson (1953) and Baker et al., (1978) report that pregnancy has a minimal effect on growth of the ewe lamb and it is lactation that markedly influences growth and development. According to Palsson (1953), lactation results in sixteen month carcasses which are lighter, leaner and narrower in the quarters.

The age at which ewes suckled or unsuckled as lambs attain comparable weights, varies with breed and management. However, most reports indicate between twenty four and thirty months (Spencer et al., 1942; Williams, 1954; Mair, 1963; Canon and Bath, 1969; Tyrell et al., 1974; Tyrell, 1976; Baker et al., 1978).

Reproduction

Liveweight-reproductivity relationships in mature ewes have been widely reported (Coop, 1966; Allison and Kelly, 1978). Similar relationships are known for two-year-olds (Coop, 1964). In particular, the regression of ovulation rate (Moore et al., 1978, 1979) and multiple birth rate (ewes lambing multiples per ewe lamb lambing) (Drew et al., 1973) on premating liveweight appear independent of postweaning growth patterns.

Drew et al., (1973) report an earlier mean onset of eighteen month breeding activity in ewes fed moderate rather than high spring-summer levels of nutrition. This is surprising in view of the work of Till (1950) and Wallace (1961) who report little effect of premating nutrition. Ewe lamb parity appears to have no effect on the mean date and pattern of onset of eighteen month breeding activity (Canon and Bath, 1969; Keane, 1974b).

Tyrell (1976) reports similar levels of eighteen month oestrous activity (ewes marked per ewe joined) in ewes previously barren or parous as ewe lambs. However, extended seasonal anoestrus would be expected in ewes of very low mating liveweight (Davis, 1975).

Quinlivan et al., (1966a,b) report no significant differences in thirty month ovulation and embryo survival rate between ewes barren or parous as two-year-olds. However, there is an apparent paucity of published information on eighteen month ovulation (and embryo survival) rates of ewes previously barren or parous as one-year-olds.

First service conception rate in eighteen month (Keane, 1974c) and mature ewes (Spencer et al., 1942; Williams, 1954; Holland and Ruttle, 1966; Cannon and Bath, 1969; Tyrell, 1976; McCall, 1980) is unaffected by one-year-old lambing status.

There is evidence to suggest that parity in the immature ewe makes for a reduced incidence of dystokia and improved mothering response at the two-year-old lambing (Apps, 1953; Boaz, 1957, 1960). In fact, Kilgour (1978) states "... that it is inhumane not to get a ewe lamb pregnant!"

Several studies highlight two-year-old litter size (lambs born per ewe lambing) differences between ewes barren or parous as one-year-olds (Williams, 1954; Longrigg, 1961; Keane, 1974b; Tyrell, 1976; Baker et al., 1978). Ewe lamb parity can lead to small reductions (Smirnov, 1935; Spencer et al., 1942; Canon and Bath, 1969; Levine et al., 1978) or even increases (Apps, 1953; Sharafeldin, 1960; Sybesma, 1961; Seljanin, 1965; Suiter and Croker, 1970; Tyrell et al., 1974; Omar et al., 1977; McCall, 1980) in two-year-old litter size.

Fleece Production

One-year-old fleece weight is unaffected by pregnancy (Schandl, 1953; Lewis, 1959; Canon and Bath, 1969; Baker et al., 1978). However, lactation in the immature ewe consistently depresses eighteen month fleece weights (Spencer et al., 1942; Mair, 1963; Holland and Ruttle, 1966; Canon and Bath, 1969; Suiter and Croker, 1970; Southam et al., 1971; Tyrell et al., 1974; Tyrell, 1976; Baker et al., 1978; McCall, 1980) but this difference rarely persists to later ages (Baker et al., 1978).

Total Productivity

Most studies indicate a greater cumulative lifetime weight of lamb weaned per ewe in favour of ewes first weaning lambs when approximately fifteen months old (Briggs, 1936; Spencer et al., 1942; Omar et al., 1977; Baker et al., 1978; Levine et al., 1978; Steine, 1979). However, cumulative lifetime fleece production tends to be poorer for this class of ewe (Briggs, 1936; Spencer et al., 1942; Suiter and Croker, 1970; Tyrell et al., 1974; Tyrell, 1976).

II.7.2 Progeny Performance

Growth and Development

There are reports of both positive (Spencer et al., 1942; McGloughlin and Crowley 1971) and negative (Briggs, 1936; Canon and Bath, 1969; Keane, 1974b; Baker et al., 1978) effects of lambing at one year on lamb birthweights in subsequent years. However, these small differences are of only minor practical importance.

Although poorly correlated to lamb growth rate, McGloughlin and Crowley (1971) report a small positive effect of lambing at one year on two-year-old ewe milk production. Several other studies report only small weaning weight differences (Briggs, 1936; Canon and Bath, 1969; Keane, 1974b; Omar et al., 1977; Baker et al., 1978). However, Steine (1979) found parous one-year-old ewes weaning consistently heavier lambs following the two-year but not three-year-old lambing and attributed this to a better maternal environment or a possible relationship between ewe lamb growth rate and ability to lamb at one year.

There appears to be no published information on later liveweights of progeny born to two year and older ewes previously parous or barren at one year.

Lamb Survival

Lamb survival is generally superior as two-year-olds and when accumulated over several lambings if ewes were parous as ewe lambs (Briggs, 1936; Spencer et al., 1942; Williams, 1954; Canon and Bath 1969; Omar et al., 1977; Levine et al., 1978).

Fleece Production

The spring fleece weights of lambs born to one-year-old dams are 0.13 - 0.17 kg lighter than fleeces from lambs born to older dams (McCall, 1980).

Lamb Production

The ratio of lambs weaned per ewe present at lambing is lower for the progeny of one-year-old ewes (19% for singles, 12% for twins) compared to the progeny of two-year-old and older ewes (37% for singles, 32% for twins) (McCall, 1980). Reproductive performance at other ages is undocumented.

II.8 Early Reproduction and Selection for Improved Reproductive Efficiency

Spencer et al., (1942) suggested that the ability of ewes to show oestrus during their first winter might in some way indicate a higher level of subsequent reproductive performance. Subsequent studies have shown that these individuals do produce more lambs during their lifetime (Wiggins, 1955; Hulet et al., 1969; Hight and Jury, 1976). Ch'ang and Raeside (1957) further suggested that genetic improvement in lamb production was possible by this method of indirect selection. These latter workers subsequently reported moderate heritability estimates for number of ewe lamb oestruses and more importantly, a positive genetic (and phenotypic) correlation with subsequent reproductive performance. They concluded that number of hogget oestruses could be used as a criterion of indirect selection for lamb production in the Romney breed.

Levine et al., (1978) show that ewes able to lamb at one year produce more weight of lamb at weaning but slightly less wool over their subsequent lifetime than ewe lambs failing to lamb. However, the effectiveness of ability to lamb at one year as a predictor of future production may be breed dependent (Levine et al., 1978). Steine (1979) claims that selection for ability to lamb at one year is unlikely to lead to increases in lamb production in subsequent years.

There is no published information in the literature on the relationship between date of first oestrus and subsequent reproductive performance (Dyrmundsson, 1973). However, the negative association between day of first oestrus and duration of the ewe lamb breeding season (Dyrmundsson and Lees, 1972a, r= -0.81, P <0.001) indicates that early dates of first oestrus and high subsequent lamb production are positively related. The earlier onset of first oestrus in lambs from lines selected for high ram lamb testis diameter (Land, 1978a) suggests a genetic relationship between day of first oestrus and subsequent lamb production.

Genetic correlations between liveweight at or near 12 months of age and subsequent fertility have been studied in several breeds of sheep. Although parameter estimates vary considerably most of the evidence suggests that the correlation is positive (Young et al., 1963; Shelton and Menzies, 1968; Ch'ang and Rae, 1972). Furthermore, liveweight at this age is a practical means of indirect selection for lamb production (Ch'ang and Rae, 1972).

Hight et al., (1973) suggest that it may be possible to classify ewe lambs according to their potential lamb production on the basis of ovulation rate at one or more ewe lamb oestruses. Hull and Hanning (1980) develop this theme further.

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

III.1 Experimental Area

III.1.1 Ewe Lamb Joining Experiment (Experiment I)

The experiment was conducted on the 'Ripley Rise' leasehold property of Massey University. However, all lambs weaned by one-year-old dams were transferred to an area of the "Fertility Centre' of the Number 1 Sheep Unit of the university to facilitate recording.

III.1.2 Ewe Lamb Ovum Viability Experiment (Experiment II)

Ewe lambs were transferred from 'Ripley Rise' to an area of the 'Fertility Centre'. Ovum transplantation studies were carried out in the laboratory adjacent to the grazing area.

III.2 Animals

Ninety-four Romney and eighty-two BLX spring-born (1976) ewe lambs were available for ewe lamb joining studies. One hundred and ten spring-born (1977) Romney ewe lambs were available for ovum transplantation studies. The animals were: an unselected group that had been born and reared together (within birth years); derived from a randomly bred Romney flock by matings to Romney or Border Leicester sires; the complete age group for that year, identified by numbered brass, and plastic ear tags and, corresponding numbers were branded midside at the commencement of the trials.

One hundred cast-for-age Romney ewes served as a source of mature ewe ova. All ewes were branded midside prior to joining.

III.3 Experimental Plan and Calendar of Events

The experimental plan and calendar of events set out in Figures 3.1 and 3.2 are discussed in the following sections.

III.3.1 Experiment I

Mating Management 1977

Ewe lambs were randomized within breed into one of two flocks. Flock 1 was joined with four entire Southdown ram lambs (Joined Flock). Flock 2 was joined with two vasectomized (teaser) Perendale ram lambs (Unjoined Flock). Rams were introduced into their respective flocks on April 29. The two flocks were grazed separately until June 3 when they were recombined. Four fresh teaser Perendale ram lambs replaced the original six ram lambs.

All rams wore harnesses during joining. The crayons were changed every fourteen days according to the colour rotation commencing green, then yellow, blue, red and finally purple.

Ewes were recorded for oestrus daily from April 29 until July 22. Oestrus was indicated by crayon marks about the rump.

Mating Management 1978

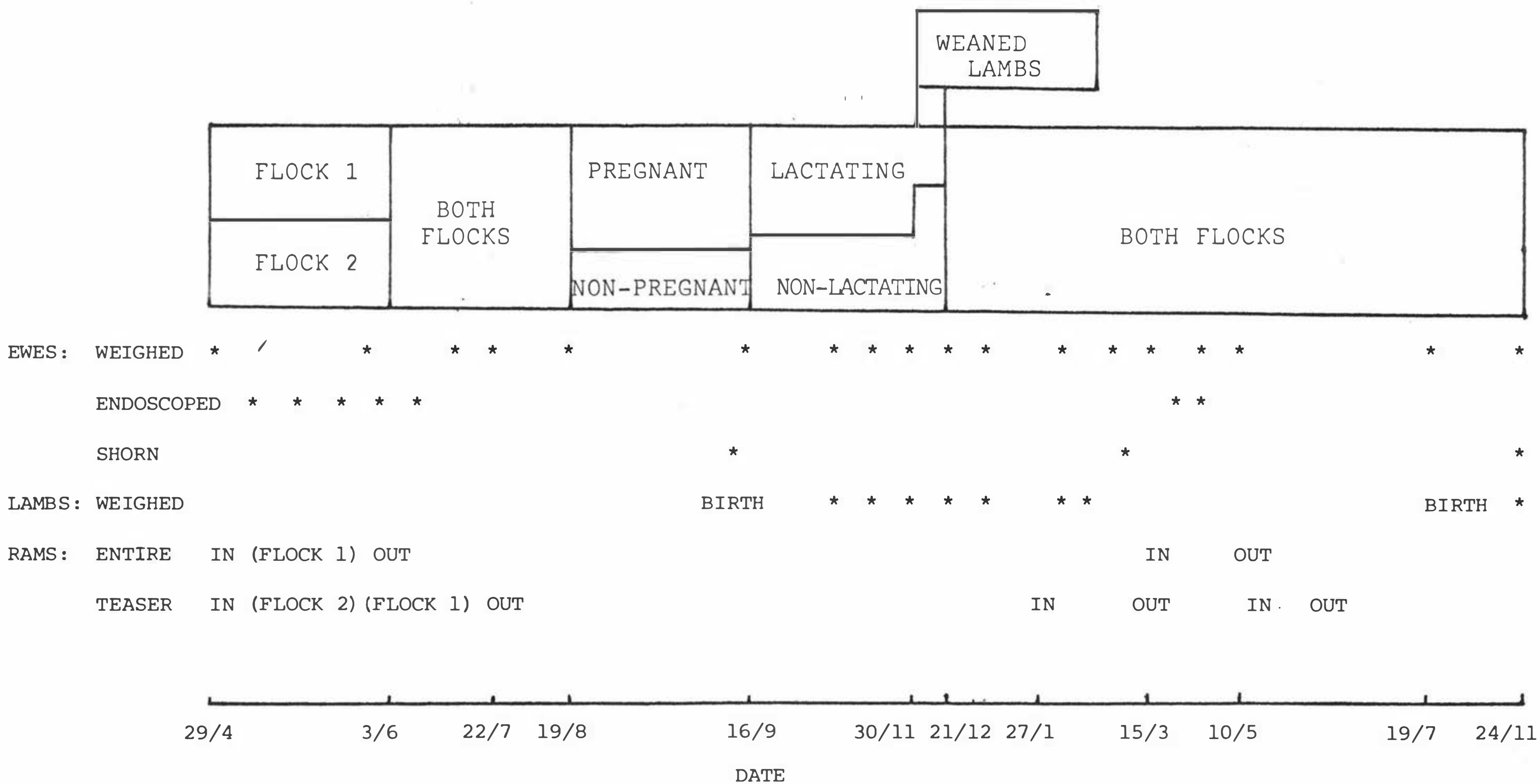
Two mature vasectomized harnessed Perendale rams were joined with all ewes from January 27 until March 15 when they were replaced by six mature entire harnessed Southdown rams. These remained until May 10. The original teaser rams were then reintroduced until withdrawn on June 24.

Crayon changes and the daily recording of oestrous ewes over the January 27 to June 24 period were as per 1977.

Liveweight

Following the initial weighing on April 29, 1977, ewes were weighed regularly at three-to-four-weekly intervals until November 22, 1978. Weighing dates are indicated in Figure 3.1.

FIGURE 3-1: EXPERIMENTAL PLAN AND CALENDAR OF EVENTS (EXPERIMENT 1)



All lambs were weighed within 24 hours of birth. Lambs born in 1977 were then weighed regularly at approximately 21 day intervals until February 13, 1978. Lambs born in 1978 were weighed at weaning on November 22, 1978.

With the exception of birthweight (recorded to nearest 0.1 kg) animals were weighed fresh off pasture to the nearest 0.5 kg.

Ovarian Activity

Ewe lambs in Flock 2 first recorded as oestrous prior to June 4, 1977 were endoscoped within one to seven days of marking. Ewes first marked between March 15 and April 5 1978 were similarly endoscoped within one to fourteen days of marking. The numbers of ovulations were recorded.

Fleece Weight

Ewe greasy fleece weight was recorded (to the nearest 0.1 kg) at shearing on September 14, 1977, February 28 and November 24, 1978.

Lambing Management 1977

Three methods were used to assess whether each ewe in Flock 1 was pregnant on August 19. Method 1 involved the use of an ultrasonic pregnancy detector (Centaur Doppler Fetometer [A]) for up to two minutes to detect foetal heart beats. Method 2 relied on the non-returns to service while Method 3 involved a visual assessment of mammary and genital development.

Animals were restrained upside-down in a wooden cradle during assessment by methods 1 and 3. All animals assessed pregnant by at least one of the three methods were grazed together from August 19 - October 21. However, those ewes assessed pregnant solely by method 2 or 3 and not showing udder and genital development commensurate with

---

A. Centaur Veterinary and Agricultural Equipment Ltd, Edinburgh their expected stage of pregnancy on September 16 were removed to be grazed with the non-pregnant group of ewes.

Therefore from docking on October 21, one grazing mob consisted of those ewes rearing lambs and all remaining ewes were grazed as a separate mob.

Newborn lambs were identified with their dams and tagged within 24 hours of birth, sex of lamb and weight of lamb were also recorded.

The dam of each lamb was scored for her behaviour toward the shepherd while the newborn lamb was held for recording purposes. Behavioural scores were: 1 (Excellent) ewe remained within one metre of lamb; 2 (Good) ewe remained within 10 metres of lamb; 3 (Fair) ewe deserted to greater than 10 metres and then returned; 4 (Poor) ewe deserted to greater than 10 metres and did not return.

Ewe udder volume was scored from 1 (Low) to 3 (High) immediately prior to the tagging of lambs (milk potential score).

Lambing Management 1978

Lambs were identified with their dams and tagged within 24 hours of birth. Date of birth, sex of lamb, birth rank and birthweight were recorded.

Weaning 1977

Lambs were randomized within breed of dam and sex into one of two weaning groups. Group 1 was weaned on November 30 at a mean age of approximately eight weeks (Early Weaned). Group 2 was weaned on December 21 at a mean age of approximately eleven weeks (Late Weaned). Lambs were transferred at weaning to the No. 1 Sheep Unit and grazed as one mob from December 21 until the final weighing on February 13.

At weaning, recently weaned ewes were removed to graze with the remaining ewes. On November 30, 45 mixed-age ewes were added to the group of lactating ewes to maintain the pre-weaning stocking rate.

These alien ewes were removed on December 21.

All ewes grazed as one mob from December 21, 1977 until November 24, 1978.

Weaning 1978

All lambs were weaned on November 22.

III.3.2 Experiment II

Mating Management and Oestrous Synchronization

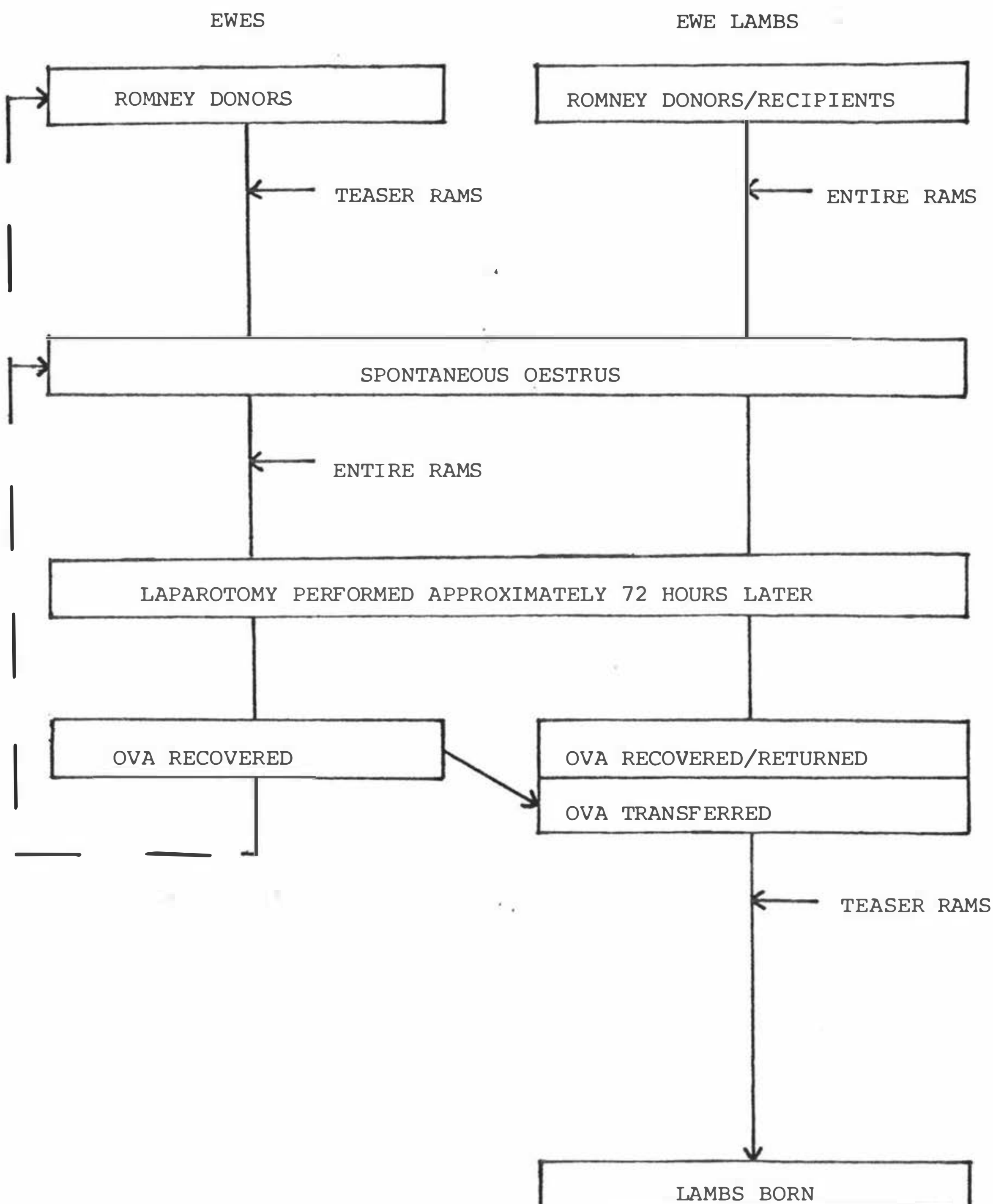
Ewe lambs were joined with three harnessed mature Suffolk rams on April 29, 1978. Three mature vasectomized harnessed Perendale rams were coincidentally joined with mature donor ewes in an adjacent paddock. The two mobs were observed twice daily (0800 and 1600 hours) and all marked animals removed at each observation time. The presence or absence of sperm in the vagina of each marked ewe lamb was then determined following swabbing and microscopy (see Edey et al., 1978). These ewe lambs were then joined with three mature entire Suffolk rams in a small grassed plot adjacent to the surgery. Ewe lambs with vaginal sperm initially absent were re-examined at the next observation period.

At each observation period, marked ewe lambs were randomly paired with coincidentally oestrous donor ewes. The ewes were then joined with three entire Romney rams in a small plot adjacent to the surgery. The objective was to match fertilized ova from each sire breed source for transplantation such that ova represented by lambs at term could be identified with the correct ewe of origin. Sire breeds were rotated between the two age-of-ewe groups to avoid possible confoundings of sire breed with age-of-ewe group.

Mature ewes were returned to their original grazing mob following surgery. Those returning to service were available as a source of fertilized ova. Ewe lambs were grazed with harnessed Perendale ram lambs

FIGURE 3-2:

EWE LAMB OVUM VIABILITY STUDY : EXPERIMENTAL PLAN



following surgery. These were observed daily until June 20 for returns to service.

Liveweight

All ewe lambs were weighed on April 14, immediately prior to surgery and on June 20. Weights were recorded to the nearest 0.5 kg.

Ova Recovery

Laparotomies were performed approximately 72 hours after marked animals were identified. The number of recent corpora lutea were recorded. Ova were recovered from the reproductive tract by flushing the Fallopian tube and about three cm of the most distal portion of the uterine horn. The technique used was essentially that described by Hunter <u>et al.</u>, (1955). Sterile sheep serum was used as the flushing medium. Immediately following recovery, flushings were examined under a binocular microscope (x 35 magnification). The number of ova recovered and stage of cleavage were recorded. Single cell and abnormal ova were discarded. Cleaved ova were held in glass dishes containing serum in an incubator at 35°C until required for transfer.

Ova Transfer

Ewe lamb ovum transfers were homologous and these did not take place until the matching mature ewe ovum was also present in the same glass dish. The pair were then simultaneously aspirated into sterilized Pasteur pipettes with as little serum as possible. The procedure described by Hunter <u>et al.</u>, (1955) was used to deposit the ova into the uterine horn contralateral to the ewe lamb ovary containing the corpus luteum. In all instances ewe lamb ova were homologously transferred and matched such that each breed of sire was represented by cleaved ova from different age-of-ewe groups.

Lambing Management

Ewe lambs receiving two ova at transfer were diagnosed for pregnancy on September 15 using the ultrasonic pregnancy detector as outlined earlier. Pregnant animals were then divided at random into two equal sized mobs and grazed in small adjacent plots. Both mobs were checked daily (0900 hours) until the commencement of lambing and then three times daily (0800, 1230, and 1630 hours) until all had lambed.

Newborn lambs were identified with their dams and tagged. The age-of-ewe group from which the lamb had originated was determined by birthcoat colour markings.

III.4 Methods of Analysis

Linear models were fitted to the data using the GLIM (Generalized Linear Interactive Modelling) statistical package. GLIM uses the methods described by Nelder and Wedderburn (1972).

All factors were considered as fixed effects except the error term. This was assumed to be a random variable with zero mean. Furthermore, these errors were assumed to be normally distributed for the purposes of significance testing.

In most instances when the two level factor Flock was included in a model (called the Flock Model), an additional model was also fitted to the data. This model, referred to as the Class Model, included the four, five but usually six level factor Class of ewe. The six levels are defined as follows:

1. Early Weaned (ewes that weaned lambs on November 30, 1977); 2. Late Weaned (ewes that weaned lambs on December 21, 1977); 3. Oestrous (Flock 2 ewes marked by rams during the first 35 days of the experiment); 4. Lamb Died (ewes failing to rear their 1977-born lambs); 5. Acyclic (ewes unmarked by rams over the first 35 days of the experiment) and 6. Infertile (Flock 1 ewes marked by rams over the

first 35 days of the experiment but failing to lamb). In some instances, only 4 (Classes 1, 2 and 5 combined and referred to as Pregnant, that is, those ewes lambing in 1977) or 5 (Classes 1 and 2 combined and referred to as Weaned, that is, those ewes weaning 1977-born lambs) levels were used in the models.

III.4.1 Fitting Models to Continuous Variables

The following model, which was used to describe a datum of ewe liveweight, liveweight gain, fleece weight, onset of two-year-old breeding season and oestrous cycle length (Flock Model), is typical of those used to analyse continuous data:

$$Y_{ijkl} = \mu + b_i + br_j + f_k + (bbr)_{ij} + (bf)_{ik} + (brf)_{jk} + (bbrf)_{ijk} + e_{ijkl}$$

Where μ = the overall population mean when equal subclass frequencies exist.

b_i = the main effect of the i^{th} breed of ewe (i = 1 or 2 denoting Romney or BLX respectively).

br_j = the main effect of the j^{th} birth rank of ewe (j = 1 or 2 denoting single-or twin-born ewes respectively. The very few triplet-born ewes were included with the twin-born ewes).

f_k = the main effect of the k_{th} joining flock (k = 1 or 2 denoting Joined or Unjoined Flocks respectively).

$(bbr)_{ij}$ = the effect of interaction between breed and birth rank.

$(bf)_{ik}$, $(brf)_{jk}$, and $(bbrf)_{ijk}$ are correspondingly defined.

Y_{ijkl} = the observation on the l^{th} individual, of the k^{th} flock, j^{th} birth rank and i^{th} breed.

e_{ijkl} = a random error term peculiar to the observation specified by the i, j, k and l subscripts, describing the deviation of the observation from the expected value under the model.

III.4.2 Fitting Models to Discrete Variables

Data involving binary dependant variables (for example, single versus multiple ovulating ewes) were analysed by an iterative weighted regression procedure which yielded maximum likelihood estimates of logit (P) where: Logit (P) = ln (P/1-P),

P is the proportion of individuals responding at one of the two levels of the variate (multiple ovulating ewes, for example) and the ratio (P/1-P) is commonly referred to as the odds ratio.

When covariates are included in the logit models the interpretation of the regression coefficients (b) is not simple, unlike the straightforward interpretation of these in a linear regression model. One interpretation of these b's is found in the property of the logit function that the odds ratio is multiplied by exponent (b) for any unit increase in the covariate (X). Hence, the coefficients will presently be discussed as odds ratio multiplicative factors.

The following model, which was used to describe the incidence of ewe lamb oestrus, is typical of those used to describe binary variables:

$$Y_{ijkl} = \mu' + b_i + br_j + f_k + (bbr)_{ij} + (bf)_{ik} + (brf)_{jk} + (bbrf)_{ijk} + b\,(X)_{ijkl} + e_{ijkl}$$

Where: $Y_{ijkl} = \ln\,(P/1-P)$

P = proportion of joined ewe lambs showing oestrus.

μ' = the overall population mean, at the zero value of the covariate X

Main effects and interactions as previously defined

b = pooled within-classes regression coefficient between Y and X.

X_{ijk} = April 29 liveweight of the l^{th} individual specified by the i, j and k subscripts.

However, the April 29 to May 27 liveweight gain covariate was also fitted as a preliminary to fitting the above covariate but in the great majority of cases proved not significant.

Where appropriate, the term C_k (the main effect of the k^{th} class of ewe) replaced f_k in the Flock Model. The number of levels for k in the Class Model is apparent from the respective analysis of variance tables.

III.4.3 Analysis of Variance (ANOVA)

The contribution of each term in the model was measured by the deviance which is analogous to sums of squares in classical least squares analysis. The deviance has an approximate χ^2 distribution in the binomial logit model.

ANOVA tables were constructed so as to yield the contribution (deviance) of each main effect over and above all remaining main effects, each two-way interaction over and above all main effects and all remaining two-way interactions. Where fitted, the deviance associated with three-way interactions were those over and above all main effects and their two-way interactions.

When one covariate was involved, the deviance over and above all other terms in the model (pooled within-classes regression) was obtained (Searle, 1971; pp 340-355).

Tests for homogeneity of regressions were carried out on the difference in deviance between the intra-class regression and the pooled within-classes regression model. This source of variation is referred to as Difference in the ANOVA tables (see Searle, 1971; pp 355-360). Where intra-class regressions were not significantly different, the pooled within-classes covariance model was retained.

III.4.4 Significance Testing

Tests of significance were carried out using the F-test for all normally distributed variables and χ^2-test for binomially distributed variables. The correction for continuity (χ^2_c) was applied to all chi-square values not arising from ANOVA tables (see Snedecor and Cochran, 1967; p 209). Duncan's New Multiple Range Test was used when more than two means were involved in a significant F-test.

Logit models were considered inappropriate when the error deviance was less than the error degrees of freedom (df).

The following symbols were used to denote the levels of statistical significance used in ANOVA tables:

Not Significant (N.S.)

$P < 0.1$	†
$P < 0.05$	*
$P < 0.01$	**
$P < 0.001$	***

Furthermore, Duncan's lettering was used to signify significantly different mean values following multiple range testing. That is, within a column, means followed by an uncommon subscript are significantly different ($P < 0.01$).

RESULTS (EXPERIMENT I)

CHAPTER IV

RESULTS (EXPERIMENT I)

IV.1 Liveweight of Ewes

A total of 166 ewes which were present at all weighings were included in the analyses. Two types of models were used to describe the data. Only breed and class of ewe effects were fitted in the Class Model. Results are presented separately for each type of model.

IV.1.1 Flock Model

The number of ewes by breed, birth rank and flock are presented in Table 4-1. Figure 4-1 shows the mean liveweights of each joining flock for Romney and BLX ewes. Mean liveweights and standard errors are presented in Appendix IA and the respective analyses of variance in Appendix IB.

Breed Effect

BLX were always heavier than Romney ewes. Although the allocation of animals was at random, the April 29 liveweight advantage of BLX ewes was greater in Flock 1 than Flock 2. This interaction approached significance. However, this interaction was significant for June 24 ($P < 0.05$), July 22 ($P < 0.05$), August 19 ($P < 0.01$) and September 16 ($P < 0.05$) weighings. At all other weighings, the breed difference in liveweight was highly significant ($P < 0.001$).

Birth Rank Effect

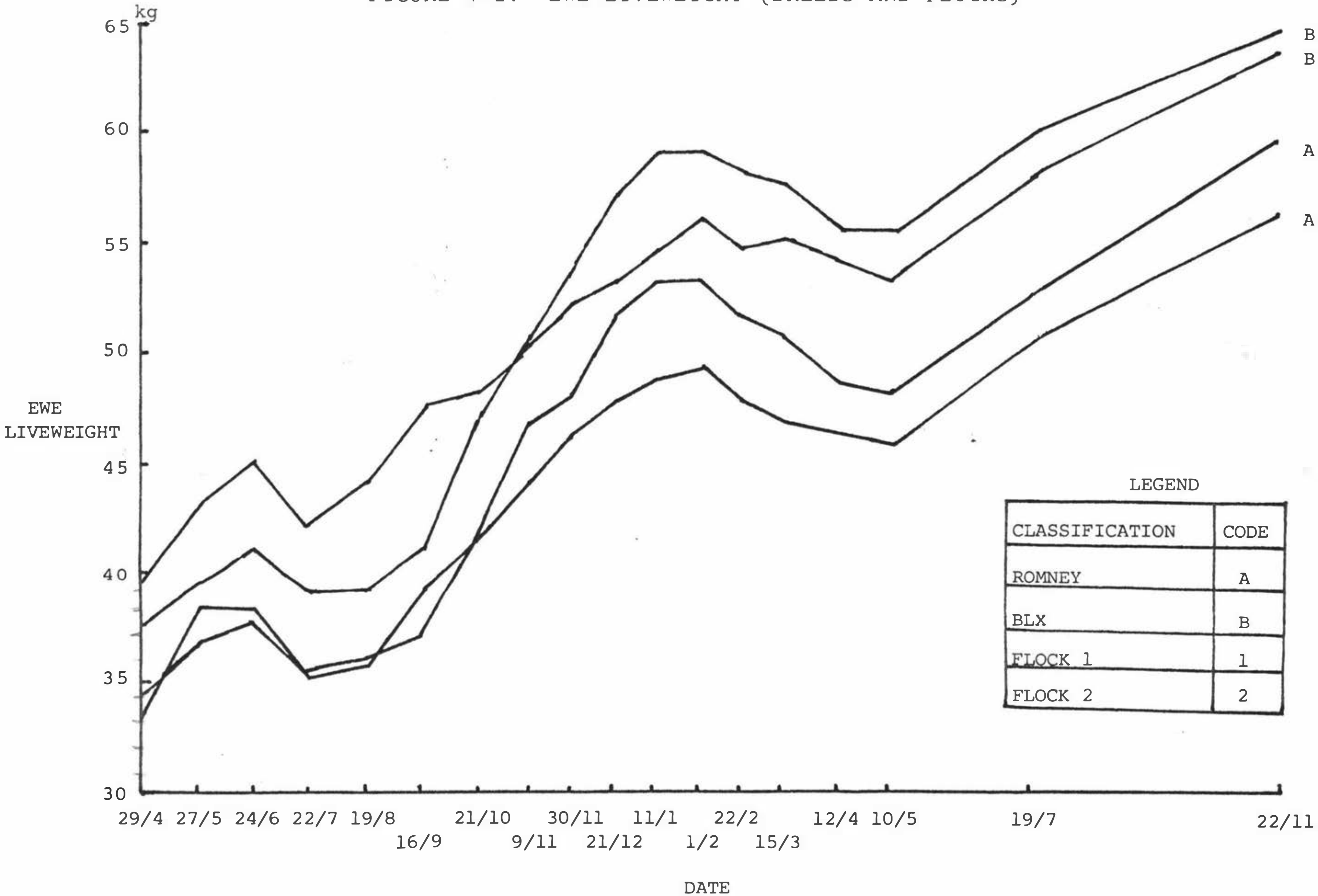
Single-born animals were always heavier than twin-born animals. This difference was significant only for April 29 ($P < 0.01$), June 24 ($P < 0.05$) and November 30 ($P < 0.05$) weighings.

The birth rank by flock interaction for July 22 liveweight ($P < 0.05$) was a result of the greater advantage of single- over twin-born ewes

TABLE 4-1 NUMBER OF EWES IN LIVEWEIGHT ANALYSES BY BREED, BIRTH RANK AND FLOCK.

Classification		Breed of Ewe		
Flock	Birth Rank	Romney	BLX	Both Breeds
Joined	Single	34	31	65
	Twin	32	27	59
	Both Birth Ranks	66	58	124
Unjoined	Single	17	12	29
	Twin	5	8	13
	Both Birth Ranks	22	20	42
Both Flocks	Single	51	43	94
	Twin	37	35	72
	Both Birth Ranks	88	78	166

FIGURE 4-1: EWE LIVEWEIGHT (BREEDS AND FLOCKS)



in Flock 2 compared to Flock 1.

Flock Effect

The breed by flock interaction over the first few weighing dates arose as a result of Flock 1 ewes weighing more than Flock 2 ewes for BLX ewes but both flocks were of similar liveweight for Romney ewes. Both Flocks were similar in liveweight on October 21 and November 9. The ewes in Flock 2 were then significantly heavier at the next eight weighings (November 30, $P < 0.05$; December 21 and January 11, $P < 0.001$; February 1, February 22 and March 15, $P < 0.01$; April 12 and May 10, $P < 0.05$). By the final weighing (November 22), Flock 2 was not significantly heavier than Flock 1. A difference of between 2 and 3 kg persisted from April 12 until the final weighing. The maximum flock difference of 4.7 kg occurred on September 16 (Flock 1 > Flock 2) and January 11 (Flock 2 > Flock 1).

IV.1.2 Class Model

The number of ewes by breed and class are presented in Table 4-2 for the four, five and six level class factor. Figures 4-2 and 4-3 show the mean liveweights of each class for Romney and BLX ewes respectively. Mean liveweights, standard errors and analyses of variance are contained in Appendix II.

Ewe liveweights recorded to September 16 were divided in four class levels for analysis. With the exception of October 21 and November 9 liveweights, which were divided into five class levels, all remaining liveweights were divided into six class levels for analysis.

April 29 to September 16 Liveweights

Since, with the exception of May 27 liveweight, breed by class interactions were significant ($P < 0.05$ - $P < 0.01$) class effects are discussed separately for each breed. Furthermore, discussion of these

TABLE 4-2 NUMBER OF EWES IN LIVEWEIGHT ANALYSES BY BREED AND CLASS

Classification	Breed of Ewe		
	Romney	BLX	Both Breeds
Class (Four level factor)			
1. Pregnant	44	45	89
2. Oestrous	21	19	40
3. Acyclic	10	6	16
4. Infertile	13	8	21
Class (Five level factor)			
1. Weaned	34	39	73
2. Oestrous	21	19	40
3. Lamb died	10	6	16
4. Acyclic	10	6	16
5. Infertile	13	8	21
Class (Six level factor)			
1. Early Weaned	16	19	35
2. Late Weaned	18	20	38
3. Oestrous	21	19	40
4. Lamb Died	10	6	16
5. Acyclic	10	6	16
6. Infertile	13	8	21

FIGURE 4-2: ROMNEY EWE LIVEWEIGHT (CLASSES)

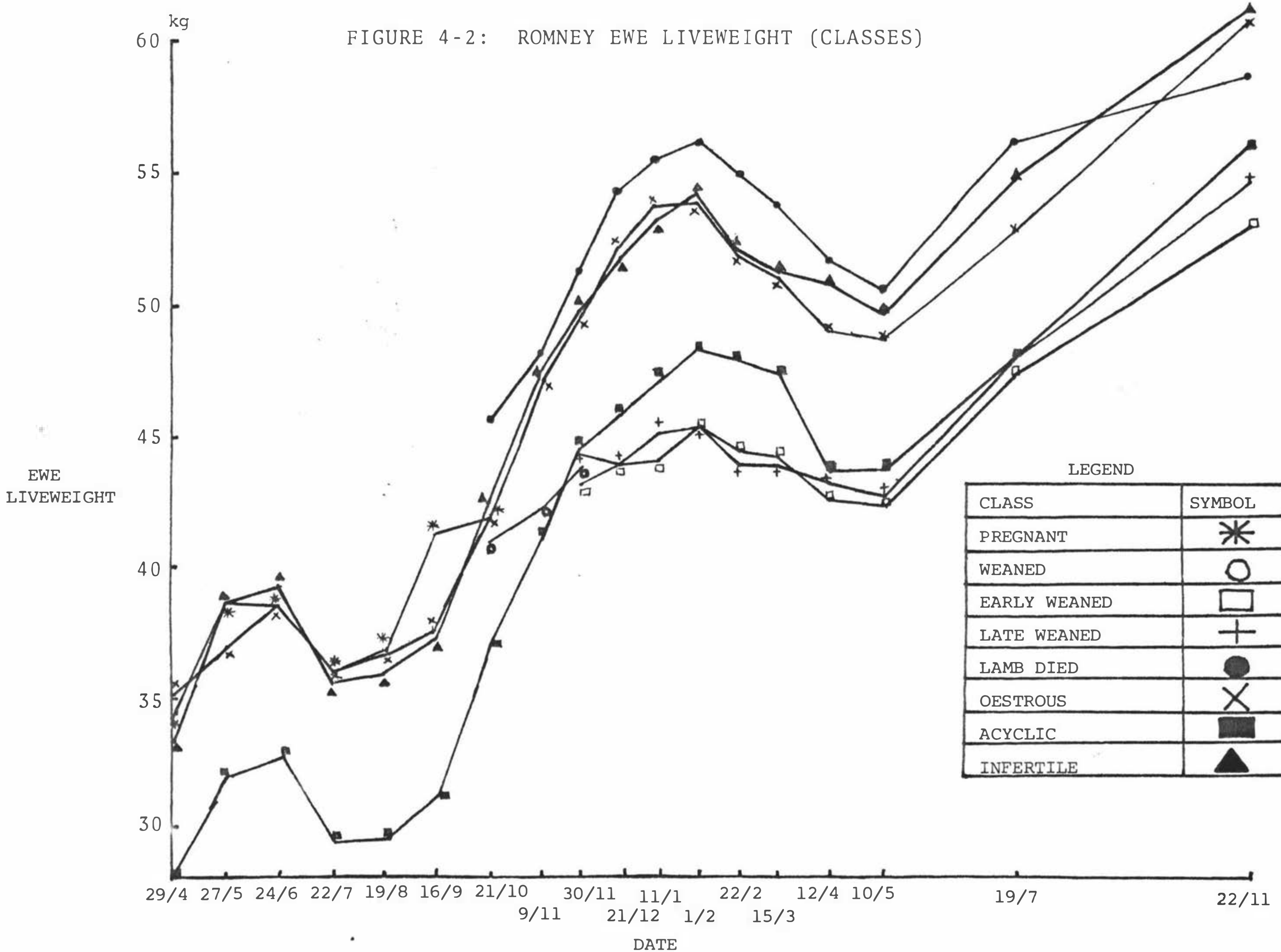
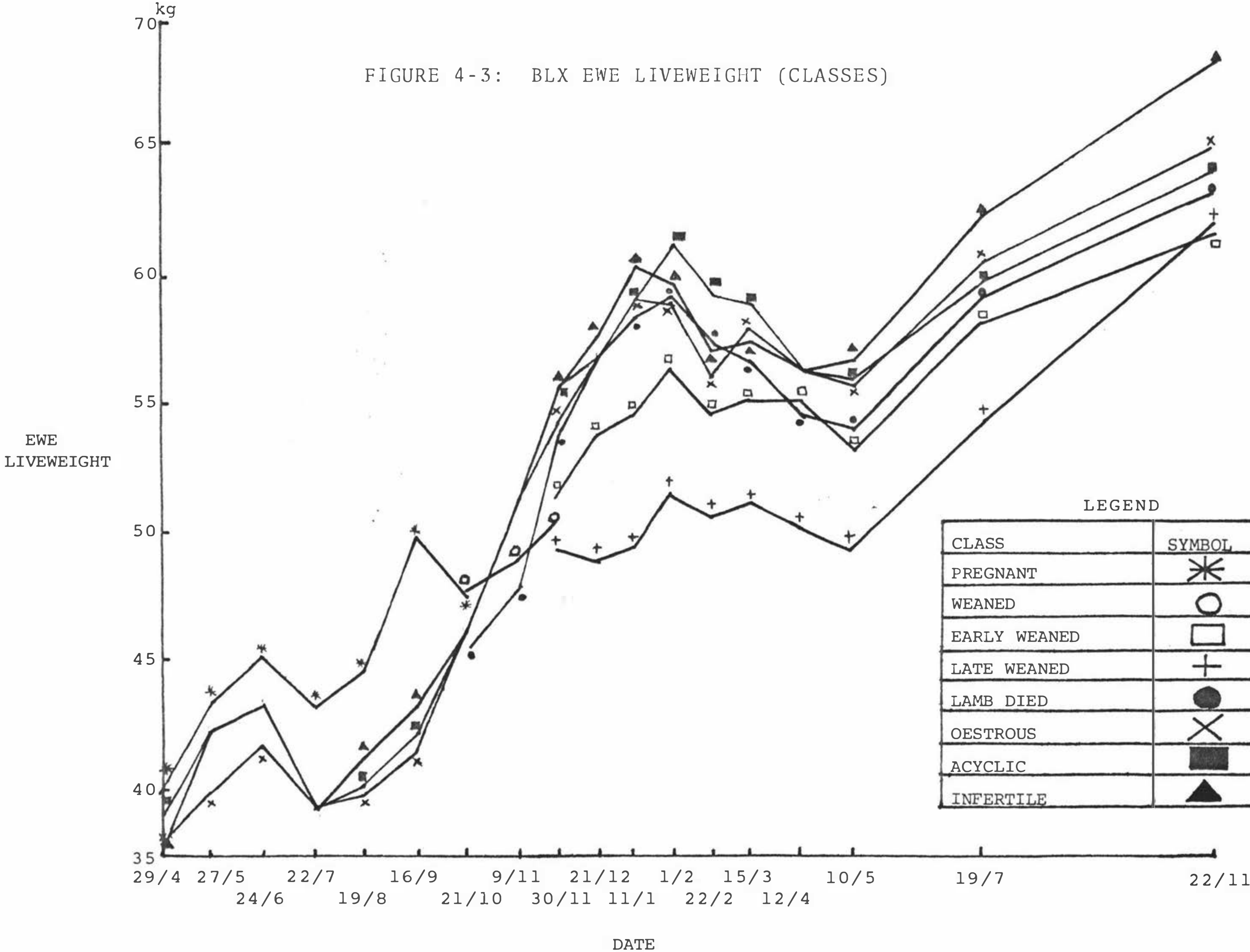


FIGURE 4-3: BLX EWE LIVEWEIGHT (CLASSES)



is restricted to three selected comparisons of interest for each of the breeds.

Class Effect (Romney Ewes)

Pregnant versus Oestrous

Ewes from both classes were very similar in liveweight until the September weighing when Pregnant ewes were significantly heavier by almost 4 kg.

Oestrous versus Acyclic

Oestrous ewes were significantly heavier than Acyclic ewes at all weighings by approximately 6 kg.

Oestrous versus Infertile

The difference in liveweight between ewes from these two classes was small (1 - 2 kg) and not significant.

Class Effect (BLX ewes)

Pregnant versus Oestrous

The liveweight advantage of Pregnant ewes over Oestrous ewes increased gradually from near 2 kg in April to be greater than 8 kg in September. The difference was significant for all except the April weighing.

Oestrous versus Acyclic

The liveweight differences between these classes were small (generally < 1kg) and not significant.

Oestrous versus Infertile

As with the situation in Romney ewes, liveweight differences were small (1 - 2 kg) and not significant.

Breed Effect

Pregnant BLX ewes were significantly heavier than Pregnant Romney ewes at all weighings. The advantage gradually increased from 5.4 kg in April to 8.5 kg in September.

With the exception of April liveweight Oestrous BLX ewes were significantly heavier than Oestrous Romney ewes by 3 - 4 kg.

The greatest liveweight advantage to BLX ewes (approximately 10 kg) was for Acyclic ewes. This difference was significant for all weighings.

Although Infertile BLX ewes were 3 - 4 kg heavier than Infertile Romney ewes until July, the differences were not significant. It was only when the difference increased to near 6 kg in August and September that the breed differences became significant.

October 21 and November 9 Liveweights

Breed Effect

BLX ewes were significantly heavier ($P < 0.001$) than Romney ewes by 5.9 and 5.5 kg at the October and November weighings respectively.

Class Effect

Acyclic ewes were significantly lighter in October than all remaining classes. None of the other class differences were significant for October liveweight. There were only two significant class differences for November liveweight: Weaned and Acyclic ewes were significantly lighter than Oestrous ewes.

November 30, 1977 to November 22, 1978 Liveweights

Since, with few exceptions (November 30, February 22, July 19 and November 22 weighings), breed by class interactions were significant ($P < 0.05$ - $P < 0.01$), class of ewe effects are discussed separately for each breed. Discussion of these is restricted to the four and five selected comparisons of interest for Romney and BLX ewes respectively.

Class Effect (Romney Ewes)

Early versus Late Weaned

The differences between Early and Late Weaned ewes failed to exceed 1.5 kg and none were significant.

Early Weaned versus Oestrous

Early Weaned ewes were significantly lighter than Oestrous ewes at all weighings. The difference increased from 6.4 kg on November 30 to a maximum of 9.6 kg on January 11 then gradually declined to 5.5 kg by July 19. A 7.2 kg difference remained at the final weighing.

Oestrous versus Acyclic

Oestrous ewes were significantly heavier than Acyclic ewes except at the final two weighings. The difference increased from 5.2 kg on November 30 to the maximum of 6.7 kg on January 11. It then varied between 5 and 6 kg until the May weighing. The difference was 4.8 and 4.0 kg at the July 19 and final weighing respectively.

Oestrous versus Infertile

Differences between these two classes of ewes were small, generally less than 1 kg, and not significant.

Class Effect (BLX Ewes)

Early versus Late Weaned

The ewes in the Early Weaned class were 2.7 kg heavier than those in the Late Weaned class on November 30. This difference was not significant. Differences at all other weighings, except the final, were significant. The difference increased to 5.0 kg by December 21 and reached a maximum of 5.3 kg at the January 11 weighing. It then fluctuated somewhat and was 3.6 kg on July 19. The difference was less than 0.4 kg at the final weighing.

Early Weaned versus Oestrous

The difference of 4.6 kg in favour of Oestrous ewes on January 11 was the maximum between these two classes and the only significant difference. The difference increased to this from 2.3 kg on November 30 and then fluctuated between 1.2 and 3.0 kg.

Late Weaned versus Oestrous

The advantage to Oestrous ewes increased from 5.0 kg on November 30 to the maximum of almost 10 kg by January 11. It then varied between

5.5 and 7.9 kg until the July 19 weighing. All of these differences were significant. However, by the final weighing the difference was only 2.6 kg and not significant.

Oestrous versus Acyclic

The ranking of these two classes was inconsistent although differences were generally less than 1 kg and none were significant. However, Acyclic ewes were heavier by 1.0, 1.9 and 3.2 kg on November 30, February 1 and February 22 respectively.

Oestrous versus Infertile

With the exception of the final weighing, when Infertile ewes were 3.7 kg heavier than Oestrous ewes, the difference failed to exceed 2 kg. None of the differences were significant.

Breed Effect.

Early Weaned BLX ewes were significantly heavier than Romney ewes at all weighings by 8 - 13 kg. Similarly Late Weaned BLX ewes were significantly heavier than Romney ewes by 5 - 7 kg.

The advantage to BLX over Romney Oestrous ewes was generally 5 - 8 kg. Apart from the final weighing, all differences were significant.

The difference between BLX and Romney Lamb Died ewes ranged between 1.9 and 4.6 kg but none of these were significant.

Apart from the 8.2 kg non-significant November 22 breed difference, BLX Acyclic ewes were significantly heavier than Romney Acyclic ewes by 11 - 13 kg.

BLX Infertile ewes were 5 - 8 kg heavier than Romney Infertile ewes and with the exception of November 30, February 22, April 12 and November 22 liveweights, the breed differences were significant.

IV.2 Liveweight Gain of Ewes

Analyses were carried out on ewe liveweight gain over six time periods as well as over the entire duration of Experiment I. The six time periods were: 1. April 29 to September 16 (first winter); 2. September 16 to November 30 (second spring); 3. November 30 to February 1 (second summer); 4. February 1 to May 10 (second autumn); 5. May 10 to July 19 (second winter) and 6. July 19 to November 22 (third spring). Time period 7 was from April 29 to November 22 (total).

In addition, liveweight gains during the April 29 to May 27, November 30 to December 21, December 21 to January 11 and March 15 to April 12 intervals were analysed so that the shorter term effects of various factors on liveweight gain could be evaluated.

IV.2.1 Flock Model

Mean (± S.E.) liveweight gains are presented in Appendix IIIA with the respective analyses of variance in Appendix IIIB.

Breed Effect

BLX ewes gained more liveweight over time periods 1 ($P < 0.001$); 3 and 4 ($P < 0.05$) and 7 (N.S.). The respective advantages were 2.6, 1.0, 1.0 and 1.1 kg. Romney ewes gained 2.4 kg ($P < 0.01$), 0 kg (N.S.) and 1.1 kg (N.S.) more than BLX ewes over time periods 2, 5 and 6 respectively.

Birth Rank Effect

Birth rank effects were generally small (< 1 kg) with twin-born ewes gaining more during five of the seven periods. The advantage to this rank was only 0.4 kg for the total period.

Flock Effect

Joined ewes gained more liveweight than Unjoined ewes over time periods 1 (4.3 kg, $P < 0.001$); 4 (1.0 kg, $P < 0.05$) and 5 (0.5 kg, N.S.) with the reverse the case for time periods 2 (7.0 kg, $P < 0.001$); 3 (1.2 kg, $P < 0.01$) and 7 (2.6 kg, $P < 0.05$). The flock effect was negligible for time period 6.

IV.2.2 Class Model

The mean (± S.E.) gains and ANOVA tables are contained in Appendices IVA and IVB.

April 29 to September 16 Gain

Class was fitted as a four level factor for this variable. The significant breed by class interaction ($P < 0.01$) necessitated the interpretation of class differences on a within - breed basis and breed differences on a within-class basis. Thus, Pregnant ewes gained significantly more than each of the remaining classes, an effect consistent for both Romney and BLX ewes. Furthermore, there were no significant differences between these three classes within either genotype.

The breed effect was consistently in favour of BLX ewes but only the difference between Pregnant ewes was significant.

September 16 to November 30 Gain

There were five levels of the Class main effect. Of these, Weaned ewes gained significantly less than the remainder. Similarly. Lamb Died ewes gained significantly less than the three remaining classes, each of which was not significantly different from each other. It should be noted that the breed by class interaction approached significance.

The six level main effect Class was used to analyse liveweight gains over the second summer, autumn and winter as well as the third spring.

November 30 to February 1 Gain

Lamb Died ewes gained the most weight over the second summer (5.1 kg). This was significantly higher than the gains achieved by Early Weaned and Late Weaned ewes. The four remaining differences with Late Weaned ewes, which gained the least (1.6 kg), were all significant. The advantage to Early Weaned ewes was only 1.8 kg. None of the remaining differences were significant.

February 1 to May 10 Gain

The negative gains over this period indicate that ewes lost weight during their second autumn.

Late Weaned ewes lost 0.9 kg less than Early Weaned ewes (N.S.) but approximately 2 kg less than Oestrous and Infertile ewes. These differences were significant. Other differences were considered of lesser importance.

May 10 to July 19 Gain

Class differences in gain over the second winter were never greater than 1.2 kg and none were significant.

July 19 to November 22 Gain

Although the range in mean gains extended from 3.0 to 7.2 kg the large variation within each class (see standard errors) meant that class differences failed to attain significance.

April 29 to November 22 Gain.

Those ewes rearing lambs to weaning at one year of age (Weaned) gained the least liveweight during Experiment I. Although Lamb Died ewes gained more, the difference was not significant. The three remaining classes gained significantly more than Weaned ewes but none were significantly different from each other. The remaining significant difference was between Infertile and Lamb Died ewes.

April 29 to May 27 Gain

Romney and twin-born ewes gained more than BLX and single-born ewes respectively (N.S.). Joined ewes gained significantly more ($P < 0.001$) than Unjoined ewes. However, it should be noted that the breed by flock interaction approached significance. The greater gain by Flock 1 ewes was particularly evident for the Infertile class of ewe. These ewes gained significantly more weight than Pregnant and Oestrous ewes. Acyclic ewes gained a similar amount of weight to Pregnant ewes and both gained significantly more than Oestrous ewes.

November 30 to December 21 Gain

Breed and birth rank effects on gain were small and not significant. Although Unjoined ewes gained only 1.7 kg more than Joined ewes, this difference was highly significant ($P < 0.001$). The reason for the difference was that ewes rearing lambs over this period (Late Weaned) gained only 1.6 kg. This was significantly less than the gains recorded by Early Weaned (3.4 kg), Infertile (4.2 kg), Oestrous (4.6 kg), Acyclic (4.7 kg) and Lamb Died ewes (5.1 kg). The differences between the latter four classes were not significant.

December 21 to January 11 Gain

Breed, birth rank and flock differences were small (< 0.7 kg) and not significant.

The difference between Early and Late Weaned ewes was small (0.2 kg) and while both classes gained less than Oestrous and Infertile ewes, only the differences with Early Weaned ewes were significant.

March 15 to April 12 Gain

Ewes lost weight over this period, the first 28 days of the two-year-old ewe mating season. Differences between breeds, birth ranks and flocks were small (< 0.8 kg) and not significant.

The differences in loss between Early Weaned, Late Weaned and Infertile ewes were small (< 0.3 kg) and not significant. The only significant difference was between Acyclic ewes (-2.6 kg) and Late Weaned ewes (-0.9 kg).

IV.3 Ewe Lamb Performance

IV.3.1 Incidence of Oestrus

A preliminary fitting of the logit model indicated that it was inappropriate for describing variation in the incidence of ewe lamb oestrus (error X^2 = 83.826, 166 d.f.).

Table 4-3 contains the effects of breed, birth rank and flock on the incidence of joined ewes displaying oestrus between April 29 and June 3. There is very little difference between each level of these three main effects.

IV.3.2 Inter-oestrus Interval

The mean (± S.E.) interval between successive heat periods was 17.22 (± 0.54) and 17.72 (± 0.41) days for Romney and BLX lambs respectively. The three shortest intervals were of 5, 10 and 12 days duration while the seven longest intervals were 22,(3x), 23, 28, 29 and 34 days long. The distributions of intervals of varying durations are presented in Figure 4-4. Breed differences, within the same interval, were small and not significant ($\chi^2_c < 2.71$). The pooled (over both breeds) data showed only 55% of the inter-oestrus intervals were 16, 17 or 18 days long.

IV.3.3 Number of Oestruses

The mean (± S.E.) number of oestruses per ewe lamb was 3.5 (± 0.3) (range 1 to 6) and 3.2 (± 0.2) (range 1 to 5) for Romney and BLX lambs respectively. The distribution of lambs showing 1 to 6 oestruses is shown in Figure 4-5. The breed differences, within the same number of oestruses, were not significant ($\chi^2_c < 2.71$). However, while similar numbers of Romney lambs displayed oestrus 2, 3 or 4 times, the number of BLX lambs increased from 2 to 3 to 4 oestruses.

The mean duration from first to last oestrus was approximately 43 days for Romney and 39 days for BLX ewe lambs.

TABLE 4-3 EFFECT OF BREED, BIRTH RANK AND FLOCK ON THE INCIDENCE OF EWE LAMB OESTRUS

Classification:	No.	Incidence of Ewe Lamb Oestrus (%)
Breed		
Romney	93	89.2
BLX	83	92.8
Birth Rank		
Single	99	89.9
Twin	77	92.2
Flock		
Joined	131	89.3
Unjoined	45	95.6

FIGURE 4-4: DISTRIBUTION OF INTER-OESTRUS INTERVALS IN ROMNEY AND BLX LAMBS (FLOCK 2)

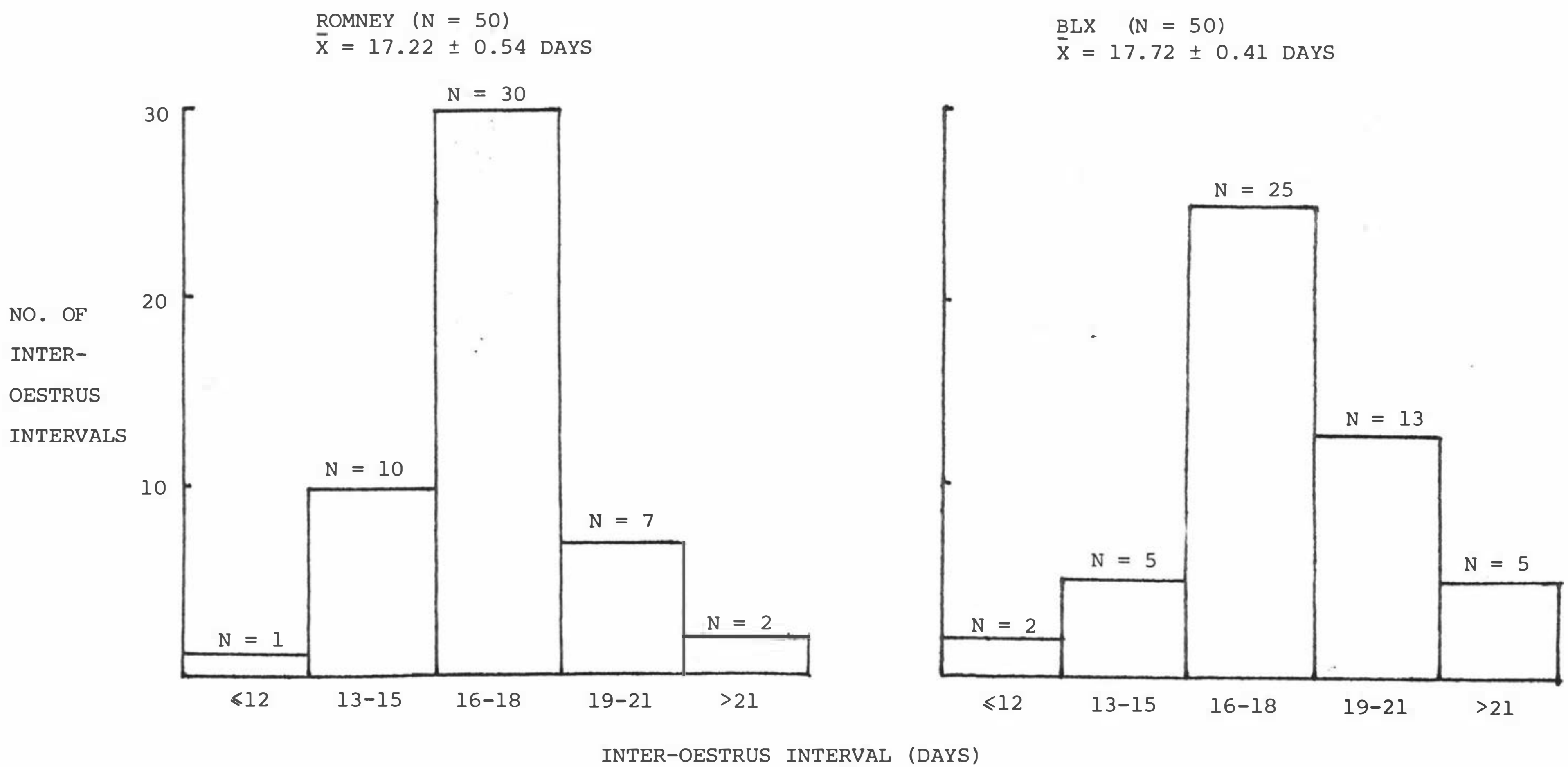
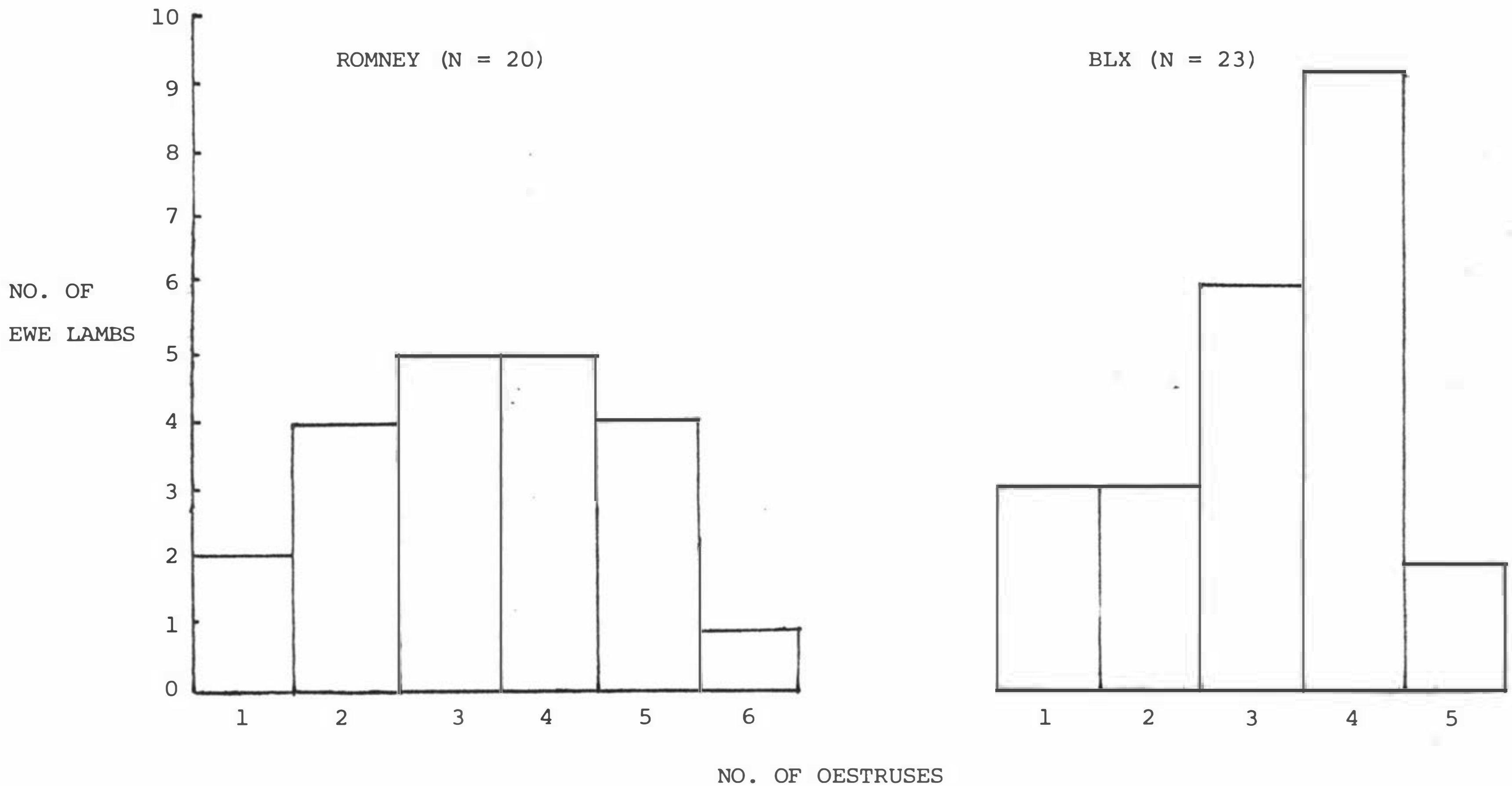


FIGURE 4-5: DISTRIBUTION OF NO. OF OESTRUSES : ROMNEY AND BLX EWE LAMBS (FLOCK 2)



IV.3.4 Incidence of Multiple Ovulation

One ewe lamb (Romney, single-born) was recorded as a triple ovulator. Another (BLX, single-born) was anovular; a single large (> 10 mm) unruptured follicle was observed. This lamb was included as a single ovulator for purposes of analysis. A total of 42 ewe lambs were endoscoped.

Only five animals (11.9%) were recorded with more than one ovulation. The logit model proved to be inappropriate for this variable (error χ^2 = 27.258, 37 d.f.).

More BLX than Romney and single-born than twin-born ewe lambs shed more than one ovum (Table 4-4).

IV.3.5 Conception

A total of 118 and 132 ewe lambs are included in the analyses of conception per ewe lamb marked, and joined respectively. In this and subsequent results, conception is used in a broad sense to include both becoming pregnant as well as lambing, that is, giving birth (whether prematurely or otherwise) is regarded as synonymous with conceiving.

Marked Ewes - First Service

The effect of breed, birth rank and April 29 - May 27 liveweight gain on the incidence of conception following first service in marked ewe lambs are presented in Table 4-5. A preliminary model fitting showed no significant regression on April 29 liveweight.

Overall, conception to first service is 74.6%. Significantly more ($P < 0.05$) BLX than Romney lambs conceived following first service. Although twin-born lambs were more fertile than single-born lambs, the difference was not significant.

The regression on April 29 - May 27 liveweight gain was significant ($P < 0.05$). This is illustrated in Figure 4-6 for the pooled over all

TABLE 4-4 EFFECT OF BREED AND BIRTH RANK ON THE INCIDENCE OF EWE LAMB MULTIPLE OVULATION

Classification:	No.	Incidence of Multiple Ovulation (%)
Breed of Ewe Lamb		
Romney	22	4.6
BLX	20	20.0
Birth Rank		
Single	28	14.3
Twin	14	7.1

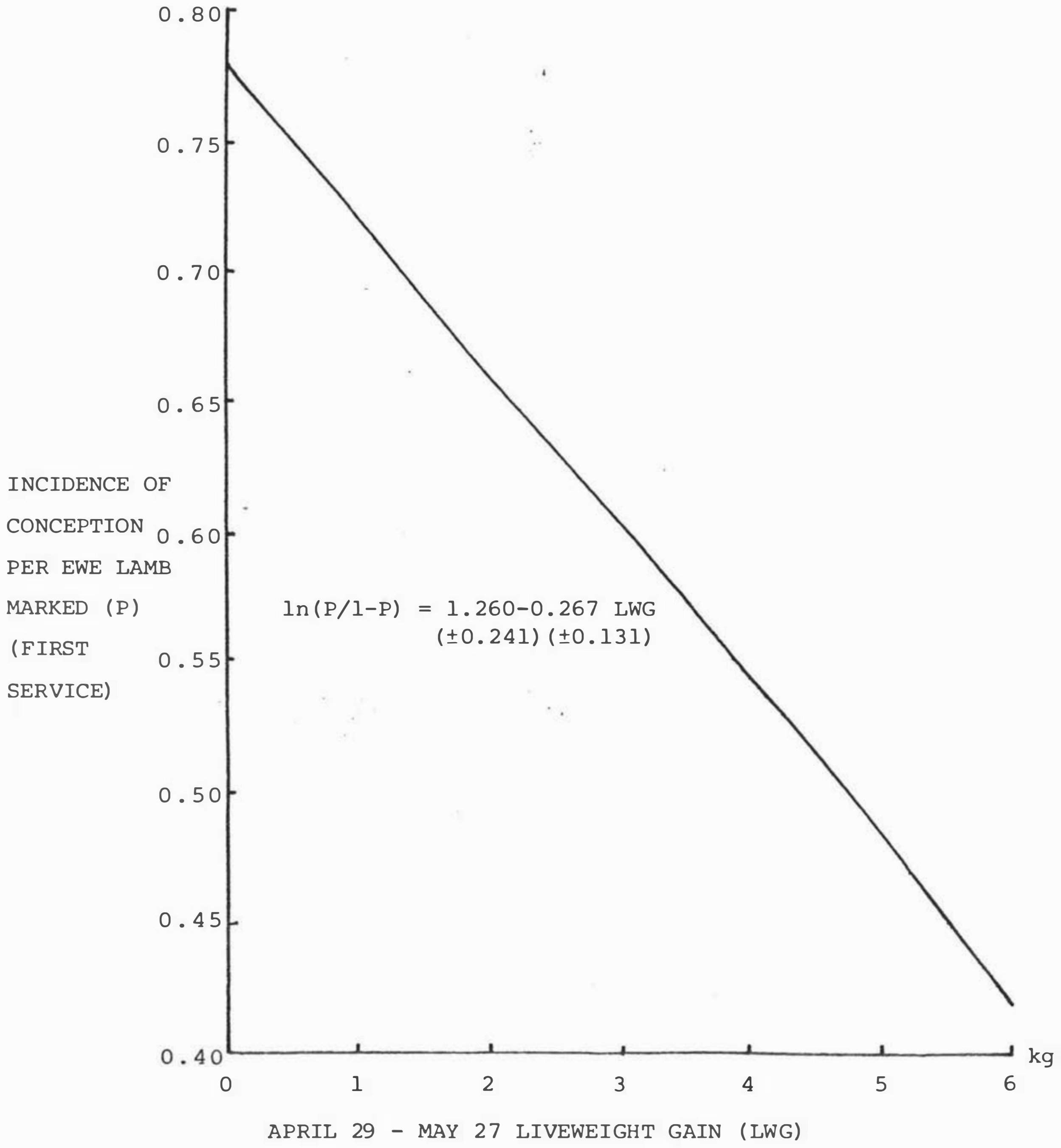
TABLE 4-5 EFFECT OF BREED, BIRTH RANK AND APRIL 29 - MAY 27 LIVEWEIGHT GAIN ON CONCEPTION TO FIRST SERVICE AND ALL SERVICES, PER EWE LAMB MARKED

Classification:	No.	Ewe Lambs Conceiving Per Ewe Lamb Marked (%)	
Breed		First Service	All Services
Romney	61	67.2	78.7
BLX	57	82.5	84.2
Birth Rank			
Single	59	69.5	78.0
Twin	59	79.7	84.7

ANOVA

Source of Variation	d.f.	Deviance (First Service)	Deviance (All Services)
Breed	1	3.880*	0.642
Birth Rank	1	1.565	0.790
Breed x Birth Rank	1	0.348	2.138
Pooled within-class regression on April 29 - May 27 liveweight gain	1	4.472*	-
Error	113	123.742	109.997 (114 d.f.)
Total	117		

FIGURE 4-6: REGRESSION OF CONCEPTION PER EWE LAMB MARKED (P) ON APRIL 29 - MAY 27 LIVEWEIGHT GAIN (LWG)



observations regression. Breed differences approached significance when considered at the same mean liveweight gain (χ^2 = 2.879). Increases in liveweight gain were associated with decreases in conception; the odds ratio was reduced by a factor of 1.306 per kg increase in gain.

Marked Ewes - All Services

The effect of breed, birth rank and April 29 - May 27 liveweight gain on the incidence of conception in marked ewe lambs are presented in Table 4-5. No covariate was fitted in the model since the error chi-square value would be reduced to 103.739 (for April 29 - May 27 liveweight gain) indicating an inappropriate model. As it is, the main effects model is not the most appropriate one (error χ^2 = 109.997, 114 d.f.).

The overall conception rate was 81.4% with only small breed and birth rank effects.

Joined Ewes - First Service

The effect of breed, birth rank and April 29 liveweight on conception following first service, per ewe lamb joined, are shown in Table 4-6. A preliminary model fitting indicated no significant regression on April 29 - May 27 liveweight gain.

On average, two out of three joined lambs conceived to first service markings. Significantly more ($P < 0.05$) BLX than Romney lambs conceived. The advantage to twin-born lambs was not significant.

The regression on April 29 liveweight was significant ($P < 0.05$). The relationship, when pooled over all observations, is illustrated in Figure 4-7. Increasing April 29 liveweight was associated with an increasing conception rate. Although breed differences were not significant, birth rank differences (in favour of twins) approached significance (χ^2 = 3.685) at the same mean April 29 liveweight. The odds ratio multiplicative factor was 1.101 per kg increase in April 29 liveweight.

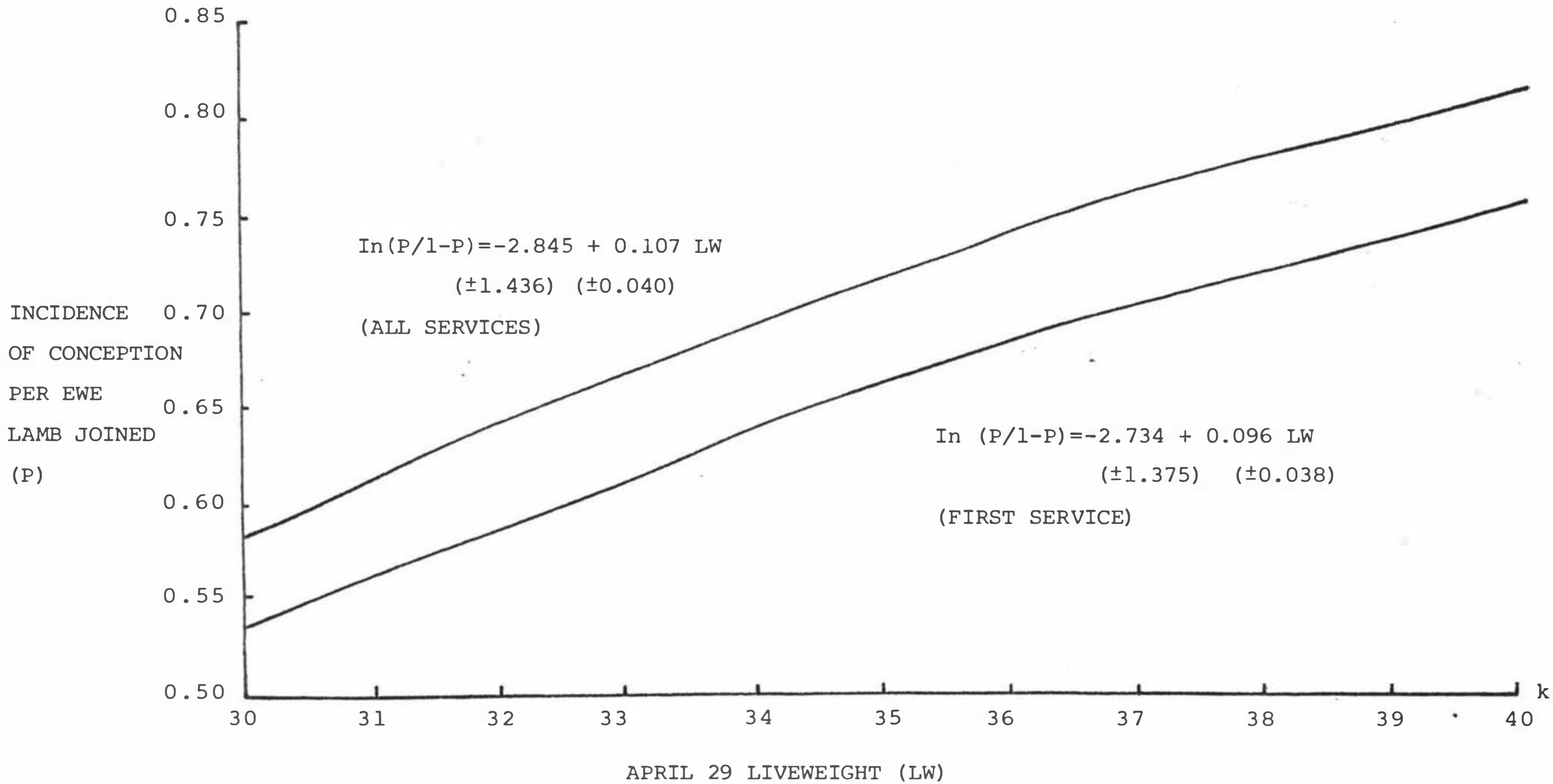
TABLE 4-6 EFFECT OF BREED, BIRTH RANK AND APRIL 29 LIVEWEIGHT ON CONCEPTION TO FIRST SERVICE AND ALL SERVICES, PER EWE LAMB JOINED

Classification:	No.	Ewe Lambs Conceiving Per Ewe Lamb Joined (%)	
Breed		First Service	All Services
Romney	70	58.6	68.6
BLX	62	75.8	77.4
Birth Rank			
Single	67	61.2	68.7
Twin	65	72.3	76.9

ANOVA

Source of Variation	d.f.	Deviance (First Service)	Deviance (All Services)
Breed	1	4.653*	0.254
Birth Rank	1	2.398	1.630
Breed x Birth Rank	1	0.093	0.977
Pooled within-classes regression on April 29 liveweight	1	4.008*	8.766**
Error	127	157.084	142.011
Total	131		

FIGURE 4-7 : REGRESSION OF CONCEPTION PER EWE LAMB JOINED (P) ON APRIL 29 LIVEWEIGHT (LW)



Joined Ewes - All Services

The effect of breed, birth rank and April 29 liveweight on conception following all services, per ewe lamb joined, are shown in Table 4-6. The pooled within-class regression on April 29 - May 27 liveweight gain was not significant.

72.7% of all joined ewes conceived as a result of one or more services. The 8 - 9% difference between BLX and Romney as well as single- and twin-born ewes was not significant.

The regression on April 29 liveweight was a significant ($P < 0.01$) source of variation. Figure 4-7 illustrates the pooled over all observations regression on April 29 liveweight. Although breed differences were not significant, birth rank differences approached significance ($\chi^2 = 3.427$) when considered at the same mean April 29 liveweight. The odds ratio multiplicative factor was 1.113 per kg increase in April 29 liveweight.

IV.3.6 Efficiency of Pregnancy Diagnosis

A total of 132 ewe lambs, all previously joined with entire rams, were evaluated for pregnancy status. The ewe lambs would have been from 77 - 112 days pregnant at this stage. The results are presented in Table 4-7.

Of those animals diagnosed as pregnant by methods 1 and 3, none failed to lamb. That is, there were no false-positive diagnoses of pregnancy. The incidence of false-positive pregnancy diagnoses was small for method 2.

The incidences of false-positive barrenness diagnoses were somewhat larger for all three methods. These were 16.3%, 27.9% and 42.9% for methods 1, 2 and 3 respectively.

The proportion of all ewe lambs that were correctly diagnosed as

TABLE 4-7 EFFICIENCY OF THREE METHODS OF PREGNANCY DIAGNOSIS

	Method of Diagnosis					
Outcome of Diagnosis	1		2		3	
	No.	(Ultrasonic Probe) %	No.	(Tupping Records) %	No.	(Visual Assessment) %
Pregnant	89		89		69	
Correct	89	100.0	84	94.4	69	100.0
Incorrect	0	0	5	5.6	0	0
Barren	43		43		63	
Correct	36	83.7	31	72.1	36	57.1
Incorrect	7	16.3	12	27.9	27	42.9
All Diagnoses	132		132		132	
Correct	125	94.7	115	87.1	105	79.5
Incorrect	7	5.3	17	12.9	27	20.5

either pregnant or barren was greatest for method 1 (94.7%), intermediate for method 2 (87.1%) and lowest for method 3 (79.5%).

IV.3.7 Maternal Behaviour Score

A total of 96 ewe lambs were scored for behaviour. However, as there were only a few animals in score category 4, these have been pooled with score 3 animals (Figure 4-8).

Romney ewe lambs were nearly equally distributed between the three score groups. Chi-square values indicated that none of the differences were significant ($\chi^2_c < 2.71$).

However, in the case of BLX ewe lambs, nearly 60% were scored as excellent mothers (score 1). Significantly more were scored in this group than either score 2 ($\chi^2_c = 4.255$, $P < 0.05$) or score 3 ($\chi^2_c = P < 0.01$).

The between-breed difference for score 1 animals indicated an advantage to BLX ewe lambs ($\chi^2_c = 3.512$, $P < 0.1$). There were more Romney than BLX ewe lambs in categories 2 and 3. However, in neither case was the breed difference significant ($\chi^2_c < 2.71$).

IV.3.8 Milking Ability Score

Figure 4-9 illustrates the distribution of ewe lambs between the three milking ability score groups for Romney and BLX ewe lambs.

In excess of half of the Romney ewe lambs were in score 2 while scores 1 and 3 were equally frequent. The differences between score 1 and scores 2 and 3 were both significant ($\chi^2_c = 5.297$, $P < 0.05$).

In the case of BLX ewe lambs, slightly more than 60% were in score 2. Significantly fewer were in scores 1 ($\chi^2_c = 4.558$, $P < 0.05$) and 3 ($\chi^2_c = 15.559$, $P < 0.001$). Furthermore, although more animals were in score 1 than 3, this difference was not significant ($\chi^2_c = 3.368$, $P > 0.05$).

None of the within-score breed differences were significant ($\chi^2_c < 2.71$).

FIGURE 4-8 : DISTRIBUTION OF PAROUS ROMNEY AND BLX EWE LAMBS BETWEEN BEHAVIOURAL SCORE CATEGORIES

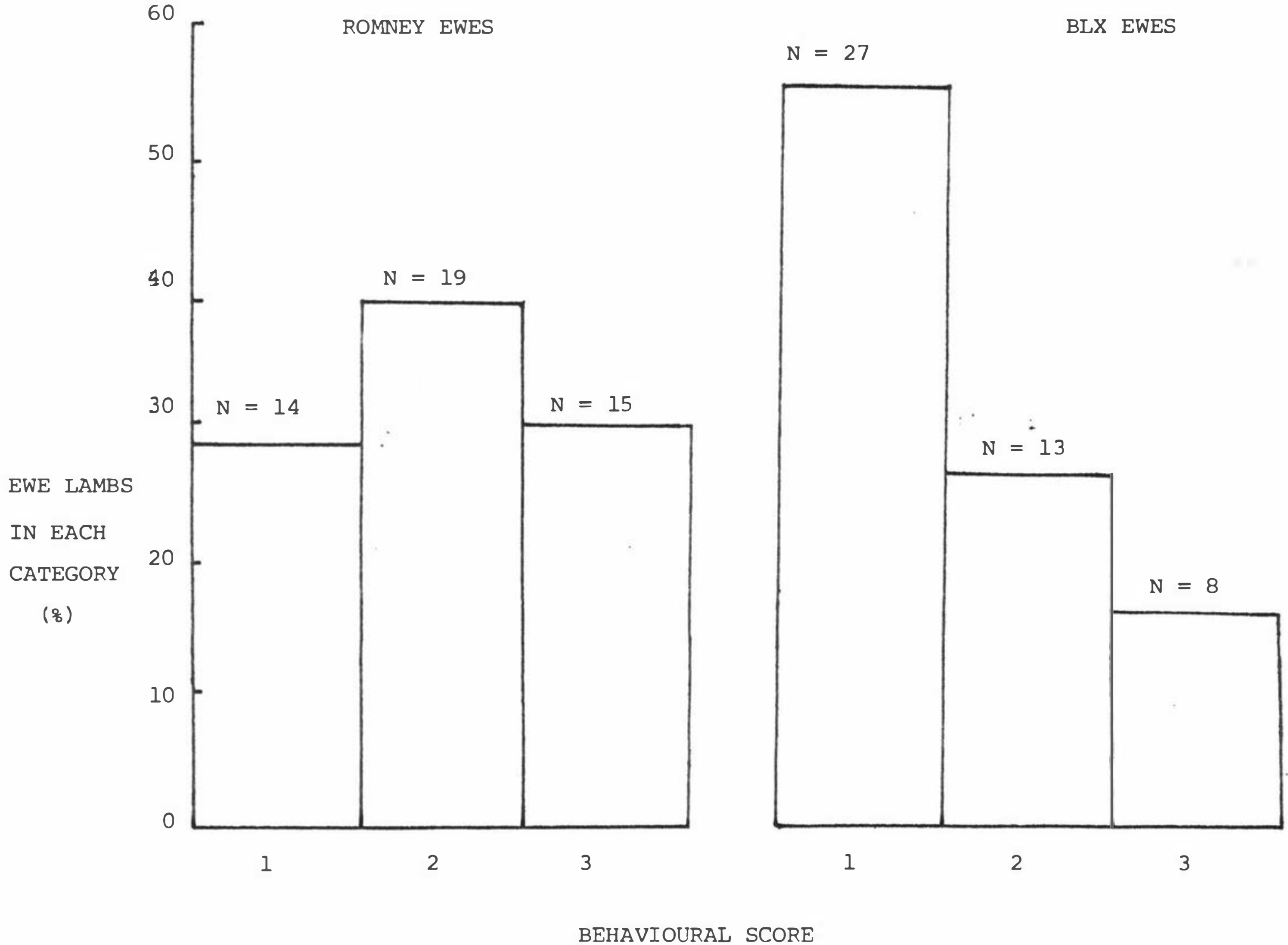
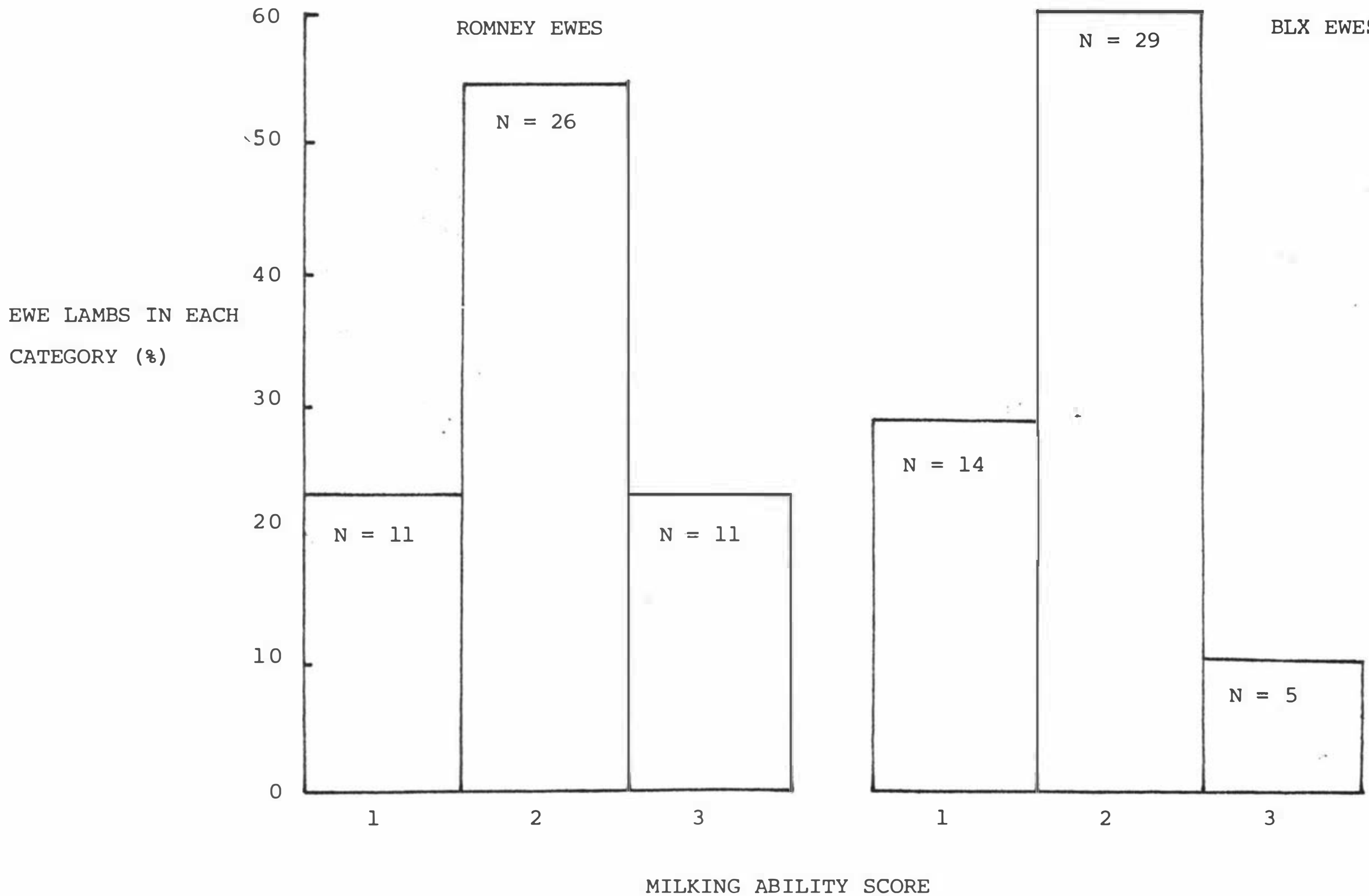


FIGURE 4-9 : DISTRIBUTION OF PAROUS ROMNEY AND BLX EWE LAMBS BETWEEN MILKING ABILITY SCORE CATEGORIES



IV.3.9 Fleece Production

The effect of breed, birth rank, flock and class (four factor levels) on September 14, 1977 fleece weight were analysed for the 166 ewes included in the ewe liveweight and liveweight gain studies. The numbers of animals involved are shown in Tables 4-1 and 4-2.

Flock Model

Breed, birth rank and flock effects are contained in Table 4-8. BLX ewe lamb fleece weights were 0.4 kg heavier than Romney fleece weights ($P < 0.001$). However, birth rank and flock effects were negligible.

Class Model

Table 4-9 contains the effects of breed and class on September fleece weight.

Pregnant, Oestrous and Infertile ewes had similar fleece weights (3.42 - 3.48 kg) which, with the exception of Infertile ewes, were significantly heavier than Acyclic ewe fleece weights (3.04 ± 0.19 kg).

IV.3.10 Lambs Weaned

Factors affecting the proportion of lambs weaned per ewe lamb marked and per ewe lamb joined are shown in Table 4-10.

Marked Ewes

The overall percentage of marked ewe lambs rearing a lamb to weaning was 65.3%.

BLX and twin-born ewe lambs weaned approximately 6% and 9% more lambs than Romney and single-born ewe lambs respectively. However, neither the breed nor the birth rank difference was significant.

April 29 liveweight and April 29 - May 27 liveweight gain did not significantly affect the proportion of marked ewe lambs weaning a lamb.

TABLE 4-8 EFFECT OF BREED, BIRTH RANK AND FLOCK ON ONE-YEAR-OLD EWE FLEECE WEIGHT

Classification:	Fleece Weight (kg) (Mean ± S.E.)
Breed of Ewe	
Romney	3.19 ± 0.08
BLX	3.65 ± 0.06
Birth Rank	
Single	3.43 ± 0.09
Twin	3.37 ± 0.07
Flock	
Joined	3.39 ± 0.10
Unjoined	3.44 ± 0.09

ANOVA

Source of Variation	d.f.	Mean Square
Breed	1	8.81***
Birth Rank	1	0.15
Flock	1	0.03
Breed x Flock	1	0.12
Breed x Birth Rank	1	0.01
Birth Rank x Flock	1	0.15
Breed x Birth Rank x Flock	1	0.01
Error	158	0.278
Total	165	

TABLE 4-9 EFFECT OF BREED AND CLASS ON ONE-YEAR-OLD EWE FLEECE WEIGHT.

Classification:	Fleece Weight (kg) (Mean ± S.E.)
Breed of Ewe	
Romney	3.19 ± 0.08
BLX	3.65 ± 0.06
Class	
1. Pregnant	3.42 ± 0.14a
2. Oestrous	3.48 ± 0.15a
3. Acyclic	3.04 ± 0.19b
4. Infertile	3.43 ± 0.12ab

ANOVA

Source of Variation	d.f.	Mean Square
Breed	1	8.43***
Class	3	0.67*
Breed x Class	3	0.13
Error	158	0.267
Total	165	

TABLE 4-10 EFFECT OF BREED AND BIRTH RANK ON LAMBS WEANED PER EWE LAMB MARKED AND PER EWE LAMB JOINED.

Classification:		Lambs Weaned (%)		
Breed of Ewe	No.	Per Ewe Lamb Marked	No.	Per Ewe Lamb Joined
Romney	61	62.3	70	54.3
BLX	57	68.4	62	62.9
Birth Rank				
Single	59	61.0	67	53.7
Twin	59	69.5	65	63.1

ANOVA

Source of Variation	d.f.	Deviance	
		Marked Lambs	Joined Lambs
Breed	1	0.533	1.061
Birth Rank	1	0.739	1.377
Breed x Birth Rank	1	0.157	0.036
Regression on April 29 - May 27 liveweight gain (Pooled within-classes)	1	2.392	2.015
Error		148.646 (113 df)	174.872 (127 df)
Total		(117 df)	(131 df)

Joined Ewes

Overall, 58.3% of joined ewe lambs reared a lamb to weaning.

BLX and twin-born ewe lambs weaned approximately 9% more lambs per joined ewe lamb than Romney and single-born ewe lambs respectively. Neither of these differences were significant.

The results of a preliminary model fitting indicated no significant effect of April 29 liveweight. Furthermore, April 29 - May 27 liveweight gain did not significantly influence the proportion of joined ewe lambs rearing a lamb to weaning.

IV.4 Ewe Lamb Progeny Performance

Analyses were carried out on pre and postnatal growth, as well as survival to weaning.

IV.4.1 Prenatal Growth

Data on gestation length, birth day and birth weight were analysed for 96 of the 99 lambs born. The three lambs not included were all co-twins to lambs randomly chosen for the analyses.

Gestation Length

The gestation period of Romney dams was approximately one day less than BLX dams (Table 4-11). This difference was not significant.

Birth rank of dam and sex of lamb effects were small and not significant.

Day of Birth

The mean date of birth was 8 October (Table 4-12). BLX ewes gave birth 6 - 7 days earlier on average than did Romney ewes ($P < 0.001$). Sex of lamb effects on day of birth were negligible.

TABLE 4-11 EFFECT OF BREED, BIRTH RANK OF DAM AND SEX OF LAMB ON GESTATION LENGTH

Classification:	No.	Gestation Length (days) (Mean ± S.E.)
Breed of Dam		
Romney	48	143.6 ± 0.8
BLX	48	144.8 ± 0.6
Birth Rank of Dam		
Single	46	144.3 ± 0.8
Twin	50	144.0 ± 0.6
Sex of Lamb		
Male	44	144.2 ± 0.8
Female	52	144.1 ± 0.6

ANOVA

Source of Variation	d.f.	Mean Square
Breed	1	34.116
Birth Rank	1	2.593
Sex	1	1.226
Breed x Sex	1	10.054
Breed x Birth Rank	1	26.499
Birth Rank x Sex	1	9.057
Breed x Birth Rank x Sex	1	4.990
Error	88	16.061
Total	95	

TABLE 4-12 EFFECT OF BREED AND SEX ON DAY OF BIRTH

Classification:		Day of Birth (January 1 = Day 1) (Mean ± S.E.)		
Breed of Ewe	No.	All Lambs	No.	Weaned Lambs
Romney	48	283.5 ± 1.7	38	284.2 ± 1.8
BLX	48	277.4 ± 1.2	39	277.2 ± 1.3
Sex				
Male	44	280.9 ± 1.8	32	280.6 ± 2.0
Female	52	280.1 ± 1.2	40	280.7 ± 1.3

ANOVA

Source of Variation	d.f.	Mean Square	
		All Lambs	Weaned Lambs
Breed	1	866.64***	959.52***
Sex	1	0.04	15.05
Breed x Sex	1	49.18	64.44
Error		68.328 (92 df)	66.345 (73 df)
Total		(95 df)	(76 df)

Birth Weight

The overall birth weight was 3.96 kg. BLX dams' progeny weighed 0.49 kg more ($P < 0.01$) than Romney dams' progeny (Table 4-13). The 0.11 kg advantage to male over female lambs was not significant.

IV.4.2 Postnatal Growth

A total of 77 lambs that were present at all weighings were included in the analyses of preweaning liveweight and liveweight gain as well as post-weaning liveweight and liveweight gain. Figure 4-10 illustrates the growth of lambs from birth to February 13.

Pre-weaning Liveweight

The effect of breed of dam and sex of lamb on October 21, November 9 and November 30 liveweights are presented in Tables 4-14 and 4-15.

October 21

BLX ewe progeny were 3.2 kg heavier than Romney ewe progeny, the difference being highly significant ($P < 0.001$). Female lambs were not significantly heavier than male lambs.

The pooled within-classes regression on day of birth was highly significant ($P < 0.001$). Furthermore, this relationship did not differ significantly between breeds of dam or sexes of lamb. October 21 lamb liveweights were reduced by 0.230 (± 0.020) kg for each day later that lambs were born.

November 9

The advantage to BLX ewe progeny over Romney ewe progeny was 3.4 kg. This difference was highly significant ($P < 0.001$). Male lambs were not significantly heavier than female lambs.

November 9 lamb liveweights varied with birth date in a manner which was significantly greater ($P < 0.01$) in BLX than Romney progeny. Thus, for every day later lambs were born, liveweight on November 9 was

TABLE 4-13 EFFECT OF BREED OF DAM AND SEX ON BIRTH WEIGHT

Classification:		Birth Weight (kg) (Mean ± S.E.)		
Breed of Dam	No.	All Lambs	No.	Weaned Lambs
Romney	48	3.71 ± 0.19	38	3.98 ± 0.16
BLX	48	4.20 ± 0.14	39	4.23 ± 0.11
Sex of Lamb				
Male	44	4.02 ± 0.20	32	4.10 ± 0.16
Female	52	3.91 ± 0.14	40	4.11 ± 0.10

ANOVA

Source of Variation	d.f.	Mean Square	
		All Lambs	Weaned Lambs
Breed	1	6.33**	1.20
Sex	1	0.72	0.01
Breed x Sex	1	1.76	0.25
Error		0.885 (92 df)	0.483 (73 df)
Total		(95 df)	(76 df)

FIGURE 4-10 : LAMB LIVEWEIGHTS (kg) : BIRTH TO FEBRUARY 13 (WEANED LAMBS)

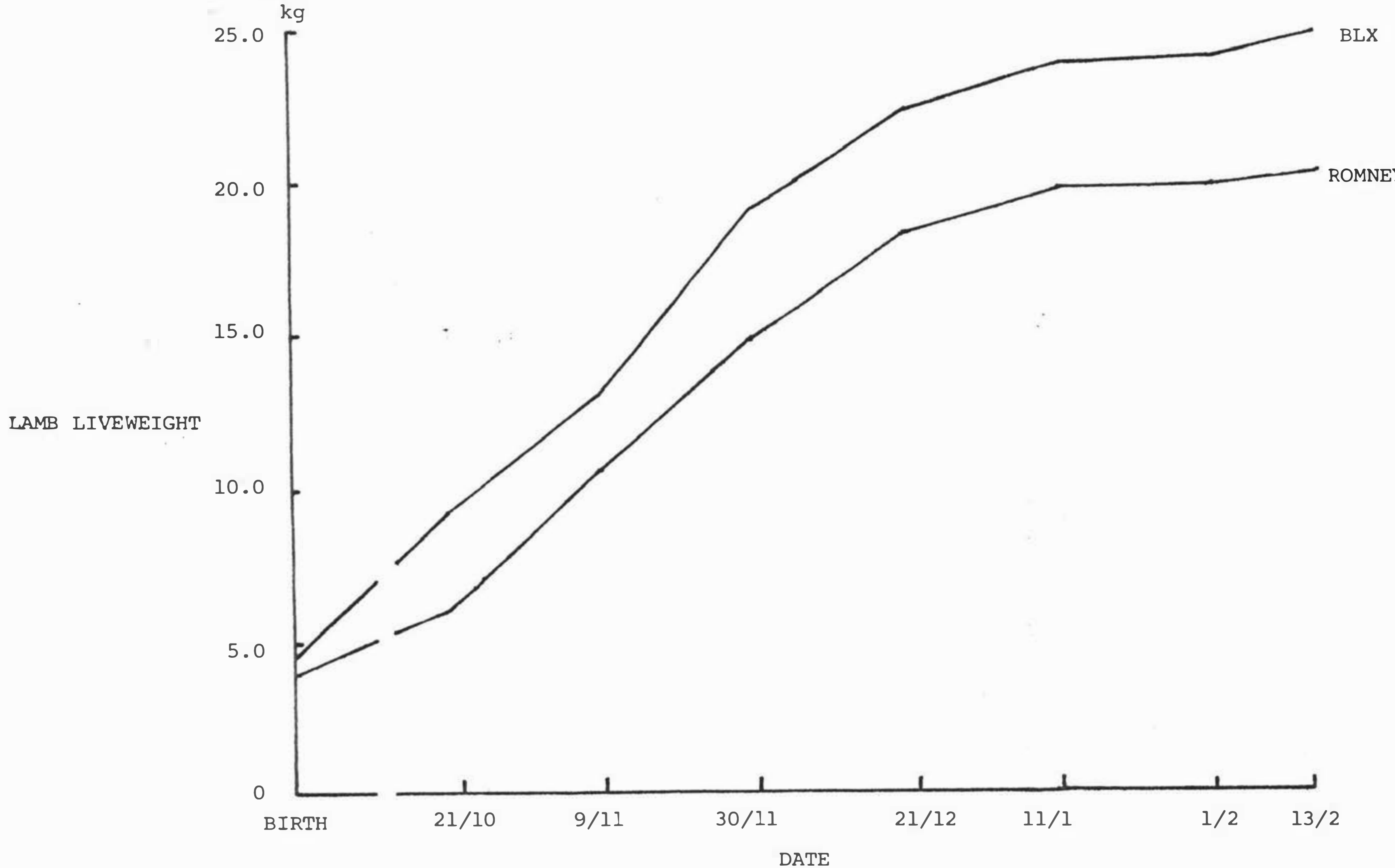


TABLE 4-14 EFFECT OF BREED OF DAM AND SEX ON PRE-WEANING LIVEWEIGHT

Classification:		Lamb Liveweight (kg) (Mean ± S.E.)		
Breed of Dam	No.	October 21	November 9	November 30
Romney	38	5.8 ± 0.5	10.4 ± 0.6	14.8 ± 0.7
BLX	39	9.0 ± 0.4	13.8 ± 0.4	18.9 ± 0.5
Sex of Lamb				
Male	32	7.2 ± 0.6	12.3 ± 0.7	17.0 ± 0.9
Female	45	7.5 ± 0.4	12.0 ± 0.5	16.8 ± 0.6

TABLE 4-15 EFFECT OF BREED OF DAM, SEX AND BIRTH DAY ON PRE-WEANING LIVEWEIGHT

ANOVA

Source of Variation	d.f.	Mean Square		
		October 21	November 9	November 30
Breed	1	195.55***	232.60***	333.97***
Sex	1	0.37	8.90	9.64
Breed x Sex	1	0.23	1.17	0.58
Regression on day of birth (within-breed)	2	-	93.09***	199.32***
Regression on day of birth (Pooled within-classes)	1	256.07***	159.17***	199.32***
Difference	1	-	27.00**	42.01*
Error	71	1.954 (72 df)	4.023	6.978
Total	76			

reduced by 0.189 (± 0.029) kg ($t = 6.51$, $P < 0.001$) and 0.263 (± 0.027) kg ($t = 9.74$, $P < 0.001$) if born to Romney and BLX dams respectively.

November 30

The breed of dam effect had increased to 4.1 kg by early weaning. This difference was highly significant ($P < 0.001$). The difference between male and female lambs remained small and not significant.

The relationship between birth day and weight was significantly different ($P < 0.05$) for each breed of dam. Thus November 30 liveweight was reduced by 0.100 (± 0.057) kg, for Romney progeny ($t = 1.75$, $P < 0.1$) and 0.287 (± 0.051) kg for BLX progeny ($t = 5.63$, $P < 0.001$), for every day later a lamb was born.

Pre-weaning Daily Liveweight Gain

The effect of breed of dam and sex of lamb on the daily increase in liveweight from birth until November 30 are presented in Table 4-16.

Lambs born to BLX dams gained daily liveweight at a greater ($P < 0.001$) rate than lambs born to Romney dams. The daily rate of gain was similar in male and female lambs.

Post-weaning Liveweight

The effect of breed of dam, weaning group and sex of lamb on December 21, January 11, February 1 and February 13 liveweight are presented in Table 4-17. Analyses of variance, which include the effects of birth day on lamb liveweight, are presented in Table 4-18.

December 21

BLX progeny were significantly heavier ($P < 0.001$) than Romney progeny. However, the difference between Early and Late Weaned lambs and male and female lambs was negligible.

The highly significant ($P < 0.001$) pooled within-classes regression on day of birth indicated a reduction in December 21 lamb liveweight of 0.201 (± 0.045) kg for every day later a lamb was born.

TABLE 4-16 EFFECT OF BREED OF DAM AND SEX ON PRE-WEANING DAILY GAIN (BIRTH - NOVEMBER 30)

Classification:	Daily Liveweight Gain (kg/day)
Breed of Dam	(Mean ± S.E.)
Romney	0.218 ± 0.10
BLX	0.257 ± 0.007
Sex of Lamb	
Male	0.236 ± 0.007
Female	0.231 ± 0.011

ANOVA

Source of Variation	d.f.	Mean Square
Breed	1	0.0297***
Sex	1	0.0016
Breed x Sex	1	0.0009
Error	73	0.0018
Total	76	

TABLE 4-17 EFFECT OF BREED, WEANING GROUP AND SEX ON LAMB POST-WEANING LIVEWEIGHT

Classification:		Lamb Liveweight (kg) (Mean ± S.E.)			
Breed of Dam	No.	December 21	January 11	February 1	February 13
Romney	38	18.2 ± 0.8	19.7 ± 0.9	19.8 ± 0.9	20.3 ± 0.9
BLX	39	22.2 ± 0.5	23.8 ± 0.6	23.9 ± 0.7	24.8 ± 0.7
Group					
Early Weaned	39	20.0 ± 0.9	21.1 ± 1.0	21.3 ± 1.0	21.8 ± 1.1
Late Weaned	38	20.5 ± 0.6	22.4 ± 0.7	22.4 ± 0.7	23.3 ± 0.7
Sex of Lamb					
Male	32	20.3 ± 0.9	21.7 ± 1.0	22.0 ± 1.1	22.8 ± 1.1
Female	45	20.3 ± 0.6	21.7 ± 0.7	21.8 ± 0.7	22.6 ± 0.7

TABLE 4-18 EFFECT OF BREED, WEANING GROUP, SEX AND BIRTH DAY ON POST-WEANING LAMB LIVEWEIGHT

ANOVA

Source of Variation	d.f.	Mean Square December 21	January 11	February 1	February 13
Breed	1	318.15***	326.02***	339.01***	396.44***
Sex	1	4.02	4.04	8.34	6.93
Group	1	5.47	35.24†	23.02	46.92†
Breed x Group	1	12.95	5.45	2.60	2.36
Breed x Sex	1	3.95	0.01	2.87	3.29
Sex x Group	1	6.42	5.74	9.18	0.72
Breed x Sex x Group	1	19.67	5.74	0.22	0.65
Regression on day of birth (within-breed)	2	-	139.77***	153.64***	-
Regression on day of birth (Pooled within-classes)	1	186.53***	232.49***	248.54***	228.36***
Difference	1	-	47.05*	58.74*	-
Error	67	9.304 (68 df)	11.493	13.251	14.621
Total	76				

January 11 and February 1

The highly significant ($P < 0.001$) liveweight advantage to BLX over Romney dam progeny remained near 4 kg. Late Weaned lambs were approximately 1 kg heavier than their Early Weaned counterparts. This difference approached significance ($P < 0.1$) for January 11 liveweight only. Male and female lambs were of similar liveweight.

The relationship between birth day and liveweight was significantly different for each breed of dam ($P < 0.05$). Thus, for every day later a lamb was born, its January 11 liveweight was reduced by 0.317 (± 0.068) kg ($t = 4.66$, $P < 0.001$) and 0.114 (± 0.074) kg ($t = 1.54$, $P < 0.1$) if born to BLX and Romney dams respectively. Furthermore, for every day later lambs were born, February 1 liveweight was reduced by 0.335 (± 0.073) kg ($t = 4.59$, $P < 0.001$) if born to BLX ewes and by 0.109 (± 0.079) kg if born to Romney ewes. The coefficient for Romney progeny was not significantly different from zero ($t = 1.38$, $P > 0.1$).

February 13

Lambs born to BLX dams were signifcantly heavier ($P < 0.001$) than lambs born to Romney dams by 4.5 kg. The 1.5 kg in favour of Late Weaned lambs approached significance ($P < 0.1$). Sex of lamb effects remained small.

The pooled within-classes regression on birth day was highly significant ($P < 0.001$). The reduction in February 13 liveweight was 0.222 (± 0.056) kg for every day later a lamb was born.

Post-weaning Daily Liveweight Gain

The effect of breed, weaning group and sex on daily liveweight gain between successive weighings from November 30 to February 13 are presented in Tables 4-19 and 4-20. In addition, the effects of these factors on daily gain from November 30 to February 13 are presented in Table 4-21.

November 30 to December 21

The progeny of Romney dams grew faster than the progeny of BLX dams. Early Weaned lambs grew slower ($P < 0.001$) than Late Weaned lambs by almost 50 g per day. Female lambs grew 11 g per day faster than male lambs (N.S.).

December 21 to January 11

Growth rates during this period were less than half that of the previous three weeks.

Both breed of dam and sex of lamb effects were small. However, a breed by sex interaction ($P < 0.1$) was, in part, the result of a small male advantage in Romney progeny but a large female advantage in BLX progeny. Late Weaned lambs grew almost twice as fast as Early Weaned lambs ($P < 0.001$). The breed by sex by group interaction approached significance.

January 11 to February 1

Lambs had almost ceased to gain liveweight over this period. Although BLX, Early Weaned and male lambs grew faster than Romney, Late Weaned and female lambs respectively, none of these main effect differences were significant. The three way interaction approached significance.

February 1 to February 13

Lamb growth was slightly improved during this interval. However, in spite of the greater rates of gain of BLX, Late Weaned and female lambs, none of the main effect differences were significant.

November 30 to February 13

The analysis of variance indicated a significant ($P < 0.01$) breed by sex by group interaction (Table 4-21).

When pooled over all observations, BLX progeny grew marginally faster than Romney progeny (0.079 ± 0.005 versus 0.074 ± 0.007kg/day); females grew slightly faster than males (0.078 ± 0.005 versus 0.076 ±

TABLE 4-19 EFFECT OF BREED, WEANING GROUP AND SEX ON LAMB POST-WEANING DAILY LIVEWEIGHT GAIN

Classification:	Daily Liveweight Gain (kg/day) (Mean ± S.E.)			
Breed of Dam	November 30 - December 21	December 21 - January 11	January 11 - February 1	February 1 - February 13
Romney	0.164 ± 0.014	0.070 ± 0.009	0.004 ± 0.018	0.047 ± 0.030
BLX	0.160 ± 0.010	0.072 ± 0.009	0.007 ± 0.012	0.076 ± 0.021
Group				
Early Weaned	0.137 ± 0.013	0.051 ± 0.012	0.012 ± 0.17	0.042 ± 0.003
Late Weaned	0.186 ± 0.009	0.090 ± 0.009	0 ± 0.012	0.080 ± 0.002
Sex of Lamb				
Male	0.156 ± 0.014	0.071 ± 0.013	0.011 ± 0.018	0.057 ± 0.031
Female	0.167 ± 0.009	0.071 ± 0.009	0.002 ± 0.011	0.065 ± 0.020

TABLE 4-20 EFFECT OF BREED, WEANING GROUP AND SEX ON LAMB POST-WEANING DAILY LIVEWEIGHT GAIN

ANOVA

Source of Variation	d.f.	Mean Square			
		November 30-December 21	December 21-January 11	January 11-February 1	February 11-February 13
Breed	1	0.17	0.05	0.12	2.24
Sex	1	1.30	0.0	0.77	0.06
Group	1	20.73***	12.97***	1.29	4.21
Breed x Group	1	0.69	1.60	0.52	0.01
Breed x Sex	1	0.36	3.64†	2.61	0.02
Sex x Group	1	0.01	0.02	0.41	4.77
Breed x Sex x Group	1	0.02	4.15†	8.19†	0.11
Error	69	1.398	1.274	2.635	2.627
Total	76				

TABLE 4-21 EFFECT OF BREED, WEANING GROUP AND SEX ON NOVEMBER 30 - FEBRUARY 13 DAILY GAIN

Classification:		Daily Gain (kg/day) (Mean ± S.E.)[A]	
Weaning Group	Sex	Breed of Dam	
Early		Romney	BLX
	Male	0.056 ± 0.013a	0.076 ± 0.013ab
	Female	0.072 ± 0.012a	0.051 ± 0.011a
Late	Male	0.086 ± 0.011ab	0.084 ± 0.013ab
	Female	0.080 ± 0.012ab	0.104 ± 0.008b

ANOVA

Source of Variation	d.f.	Mean Square
Breed	1	0.00049
Sex	1	0.00004
Group	1	0.01461***
Breed x Group	1	0.00148
Breed x Sex	1	0.00017
Sex x Group	1	0.00057
Breed x Sex x Group	1	0.00520**
Error	69	0.00078
Total	76	

A Duncan's New Multiple Range Test was used to test differences between these eight means.

0.007 kg/day) and Late Weaned lambs grew faster than Early Weaned lambs (0.090 ± 0.005 versus 0.063 ± 0.007 kg/day). The mean daily gain was 0.077 kg/day.

IV.4.3 Survival to Weaning

The effect of breed of dam and sex on lamb survival to weaning are contained in Table 4-22.

Lambs born to BLX dams were only slightly superior to lambs born to Romney dams. However, the advantage to female lambs approached significance (86.5% versus 72.7%).

When the linear and quadratic birth weight terms were separately added to the main effects model, they each contributed very little in explaining variation in lamb survival. However, when both terms were included, they contributed significantly ($\chi^2 = 32.952$, 2 d.f., $P < 0.001$) but the model was inappropriate (error $\chi^2 = 59.672$, 90 d.f.). It was therefore concluded that insufficient data is available to account for variation in survival using these birth weight covariates.

TABLE 4-22 EFFECT OF BREED AND SEX ON LAMB SURVIVAL TO WEANING

Classification:	No.	Survival to Weaning (%)
Breed of Dam		
Romney	48	79.2
BLX	48	81.3
Sex of Lamb		
Male	44	72.7
Female	52	86.5

ANOVA

Source of Variation	d.f.	Deviance
Breed	1	0.002
Sex	1	2.805†
Breed x Sex	1	0.020
Error	92	92.629
Total	95	

IV.5 Two-year-old Ewe Performance

Analyses were carried out on various aspects of productivity of ewes between 15 and 28 months of age (hereafter called two-year-old ewes).

IV.5.1 Onset of Breeding Season

The daily recording of oestrous activity permitted investigation into those factors influencing onset of the breeding season (that is, the day of first oestrus).

Flock Model

The effect of breed, birth rank and flock are presented in Table 4-23. The mean day of first oestrus was day 72 (March 13).

BLX and twin-born ewes showed first oestrus two days earlier than Romney and single-born ewes respectively. Neither of these differences were significant (Table 4-24). The flock effect was small and not significant.

Class Model

The results are presented in Tables 4-23 and 4-25.

Class of ewe (five factor level) accounted for a significant amount of variation ($P < 0.05$). Onset of the breeding season was earliest in Infertile ewes (day 65.3) and latest in Acyclic ewes (day 78.5). There was little difference between the three remaining classes. The only significant differences were Infertile ewes showing first oestrus earlier than Weaned, Lamb Died and Acyclic ewes. Early and Late Weaned ewes were pooled since the small difference (day 72.9 versus day 73.6 respectively) was not significant.

IV.5.2. Oestrous Cycle Length

Oestrous cycle length was determined for the 95 ewes first mated prior to the entire joining on March 15 (Tables 4-26 and 4-27).

TABLE 4-23 EFFECT OF BREED, BIRTH RANK, FLOCK AND CLASS ON ONSET OF TWO-YEAR-OLD EWE BREEDING SEASON

Classification:	Day of Onset (January 1 = Day 1)
Breed of Ewe	(Mean ± S.E.)
Romney	73.5 ± 1.9
BLX	71.6 ± 1.4
Birth Rank	
Single	74.5 ± 1.9
Twin	72.5 ± 1.4
Flock	
Joined	72.8 ± 2.1
Unjoined	72.1 ± 1.8
Class	
1. Weaned	73.3 ± 2.9a
2. Oestrous	72.0 ± 3.1ab
3. Lamb Died	75.1 ± 3.8a
4. Acyclic	78.5 ± 3.8a
5. Infertile	65.3 ± 2.5b

TABLE 4-24 EFFECT OF BREED, BIRTH RANK AND FLOCK ON ONSET OF TWO-YEAR-OLD EWE BREEDING SEASON

ANOVA

Source of Variation	d.f.	Mean Square
Breed	1	142.527
Birth Rank	1	2.696
Flock	1	14.695
Breed x Flock	1	10.999
Breed x Birth Rank	1	316.608
Birth Rank x Flock	1	172.185
Breed x Birth Rank x Flock	1	9.829
Error	158	144.196
Total	165	

TABLE 4-25 EFFECT OF BREED, BIRTH RANK AND CLASS ON ONSET OF TWO-YEAR-OLD EWE BREEDING SEASON

ANOVA

Source of Variation	d.f.	Mean Square
Breed	1	193.661
Birth Rank	1	2.933
Class	4	465.310**
Breed x Class	4	31.324
Breed x Birth Rank	1	59.144
Birth Rank x Class	4	254.122†
Breed x Birth Rank x Class	4	27.999
Error	146	128.112
Total	165	

TABLE 4-26 EFFECT OF BREED, BIRTH RANK, FLOCK AND CLASS ON OESTROUS CYCLE LENGTH

Classification:		No.	Oestrous Cycle Length (days)
Breed of Ewe			(Mean ± S.E.)
	Romney	45	16.2 ± 0.2
	BLX	50	16.9 ± 0.2
Birth Rank			
	Single	55	16.5 ± 0.3
	Twin	40	16.6 ± 0.2
Flock			
	Joined	67	16.6 ± 0.2
	Unjoined	28	16.5 ± 0.3
Class			
1.	Weaned	42	16.5 ± 0.4
2.	Oestrous	27	16.6 ± 0.4
3.	Lamb Died	7	16.4 ± 0.6
4.	Acyclic	5	16.4 ± 0.6
5.	Infertile	14	16.8 ± 0.3

TABLE 4-27 EFFECT OF BREED, BIRTH RANK, FLOCK AND CLASS ON OESTROUS CYCLE LENGTH

ANOVA

Source of Variation	d.f.	Mean Square	Source of Variation	d.f.	Mean Square
		(Flock Model)			(Class Model)
Breed	1	9.637**	Breed	1	10.249**
Birth Rank	1	0.072	Birth Rank	1	0.054
Flock	1	0.113	Class	4	0.507
Breed x Birth Rank	1	3.365	Breed x Birth Rank	1	3.851†
Breed x Flock	1	2.095	Breed x Class	4	1.155
Birth Rank x Flock	1	3.240	Birth Rank x Class	4	1.022
Breed x Birth Rank x Flock	1	0.033	Breed x Birth Rank x Class	2	0.831
Error	87	1.377	Error	77	1.465
Total	94		Total	94	

Flock Model

Cycle length in BLX ewes was 0.7 days longer than in Romney ewes. This difference was significant ($P < 0.01$). The remaining main effect differences were small and not significant.

Class Model

Differences between the classes were small ($\leqslant$ 0.4 days) and not significant.

IV.5.3 Incidence of Multiple Ovulation

Of the 168 ewes examined only 164 provided complete records. Two ewes were recorded with three corpora lutea. In addition, six ewes, each of which was recorded with a single corpus luteum, produced twins. These ewes were considered as multiple ovulators for analytical purposes. Sixty three (38.4%) of the recorded ewes were multiple ovulators. The effect of breed, flock and class are presented in Table 4-28 and the analyses of variance in Table 4-29.

Flock Model

Cross-bred ewes had a significantly higher ($P < 0.001$) incidence of multiple ovulation than straight-bred ewes (53.3% versus 28.1%). There was a negligible difference between Joined and Unjoined ewes.

The pooled within-classes regression on March 15 liveweight was significant ($P < 0.001$). The odds ratio multiplicative factor was 1.106 per kg increase in March 15 liveweight. Furthermore, the odds ratio multiplicative factor was greater for BLX than Romney ewes (1.192 versus 1.018 per kg increase in March 15 liveweight). However, this difference only approached significance.

Class Model

Acyclic ewes had the highest incidence of multiple ovulation (53.3%). Early Weaned, Oestrous, Lamb Died and Infertile ewes were intermediate (~40%) between these and Late Weaned ewes (27.0%). However, class of

TABLE 4-28 EFFECT OF BREED, FLOCK AND CLASS ON INCIDENCE OF MULTIPLE OVULATION

Classification:	No.	Incidence of Multiple Ovulation (%)
Breed of Ewe		
Romney	89	28.1
BLX	75	53.3
Flock		
Joined	121	39.7
Unjoined	43	39.5
Class		
1. Early Weaned	34	44.1
2. Late Weaned	37	27.0
3. Oestrous	41	39.0
4. Lamb Died	16	43.8
5. Acyclic	15	53.3
6. Infertile	21	42.9

TABLE 4-29 EFFECT OF BREED, FLOCK, CLASS AND MARCH 15 LIVEWEIGHT ON INCIDENCE OF MULTIPLE OVULATION

ANOVA

Source of Variation	d.f.		Deviance Flock Model	Deviance Class Model
Breed	1		10.919***	12.713***
Flock	1		0.002	-
Class	5		-	6.018
Breed x Flock	1		1.428	-
Breed x Class	5		-	5.949
Regression on March 15 liveweight (within-breed)	2		14.619***	11.225***
Pooled within-classes		1	11.038***	7.244**
Difference		1	3.581†	3.981*
Error			193.286 (158 df)	186.143 (150 df)
Total	163			

ewe differences were not a significant source of variation.

The pooled within-classes regression on March 15 liveweight was significant ($P < 0.01$). The odds ratio multiplicative factor was 1.103 per kg increase in March 15 liveweight. The significantly different within-breed regressions yielded values of 1.018 and 1.192 for Romney and BLX ewes respectively. Figure 4-11 illustrates the relationship for BLX ewes only as the regression coefficient for Romney ewes was not significantly different from $\ln(b) = 0$.

IV.5.4 Conception

The effect of breed, flock, class and March 15 liveweight on conception following first service and all services were studied using data from the 168 ewes present at lambing.

First Service - Single and Multiple Ovulators

Factors affecting conception rate in single and multiple ovulating ewes are shown in Table 4-30.

The logit models proved inappropriate for both single (Flock Model: error $\chi^2 = 89.729$, 94 d.f.; Class Model: error $\chi^2 = 82.550$, 86 d.f.) and multiple ovulating ewes (Flock Model: error $\chi^2 = 33.120$, 60 d.f.; Class Model: error $\chi^2 = 24.325$, 52 d.f.).

There was a 81.8% and 92.3% first service conception rate in single and multiple ovulating ewes respectively ($\chi^2_C = 0.388$, $P > 0.1$). Romney ewes were more fertile than BLX ewes if single ovulators (84.4% versus 77.1%) but less fertile if multiple ovulators (88.0% versus 95%). Joined ewes were less fertile than Unjoined ewes, particularly for single ovulators (78.1% versus 92.3%). Flock differences were negligible for multiple ovulators (91.7% versus 94.7%).

First service conception rates ranged from 66.7% (Infertile ewes) to 92.0% (Oestrous ewes) for single ovulators and 87.5% (Acyclic ewes) to 100% (Lamb Died ewes) for multiple ovulators.

FIGURE 4-11 : REGRESSION OF MULTIPLE OVULATION INCIDENCE (P) ON MARCH 15 LIVEWEIGHT (LW) (BLX EWES ONLY)

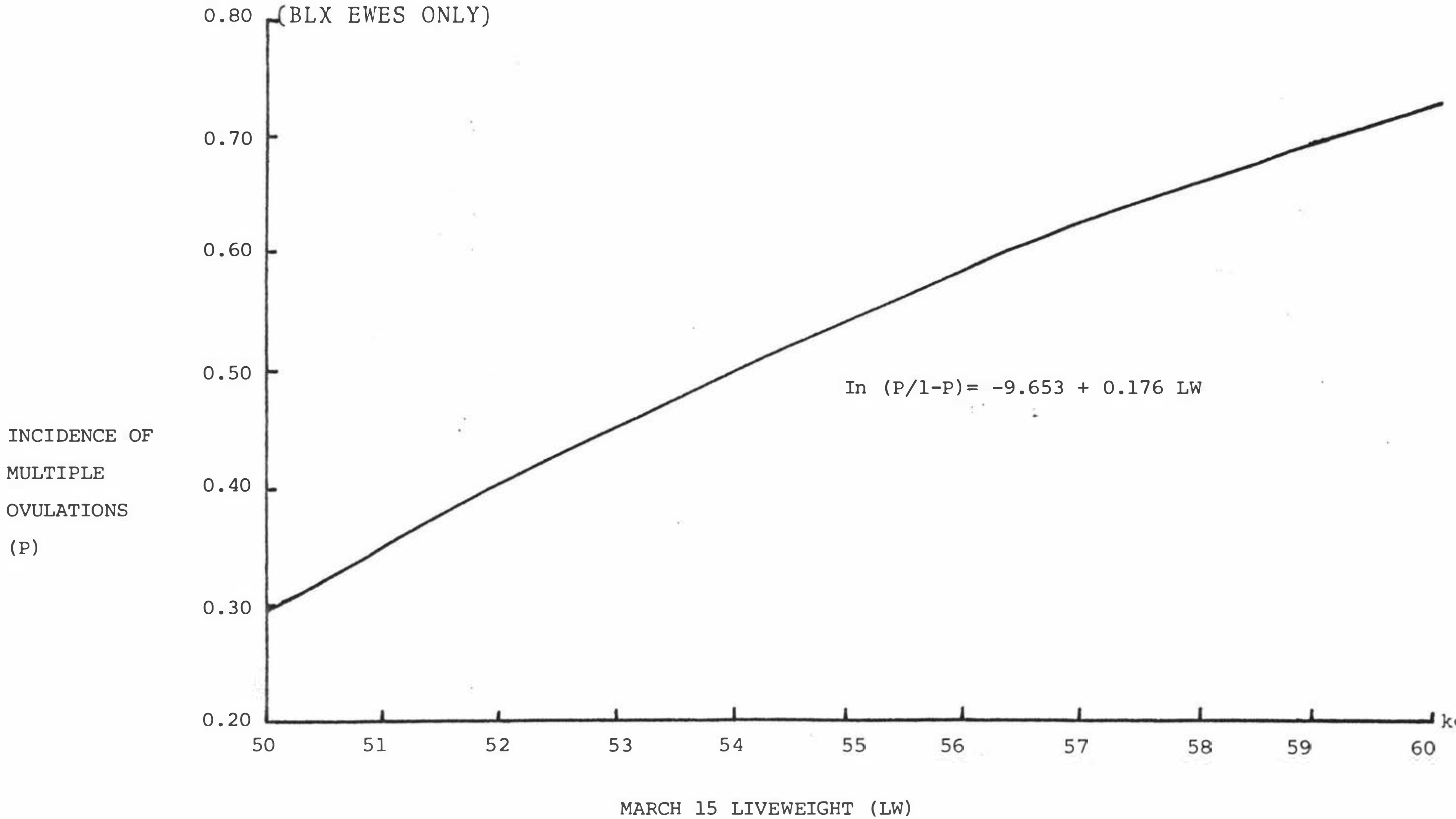


TABLE 4-30 EFFECT OF BREED, FLOCK AND CLASS ON FIRST SERVICE CONCEPTION (SINGLE AND MULTIPLE OVULATING EWES)

Classification:		Ewes Conceiving (%)		
Breed of Ewe	No.	Single Ovulators	No.	Multiple Ovulators
Romney	64	84.4	25	88.0
BLX	35	77.1	40	95.0
Flock				
Joined	73	78.1	48	91.7
Unjoined	26	92.3	17	94.7
Class				
1. Early Weaned	19	78.9	15	93.3
2. Late Weaned	27	81.5	10	90.0
3. Oestrous	25	92.0	16	93.7
4. Lamb Died	9	88.9	7	100.0
5. Acyclic	7	71.4	8	87.5
6. Infertile	12	66.7	9	88.9

First Service - All Ewes

The effect of breed, flock and class on first service conception rate are presented in Table 4-31.

The logit models proved inappropriate for this variable (Flock Model: error χ^2 = 133.907, 163 d.f.; Class Model: error χ^2 = 128.446, 155 d.f.).

When all 168 ewes present at lambing were considered, breed differences were small (Romney, 84.4% versus BLX, 85.9%). However, the difference between Joined (82.4%) and Unjoined ewes (93.0%) was larger. Class of ewe means ranged from 76.2% (Infertile) to 93.7% (Lamb Died).

All Services - All Ewes

The effect of breed, flock and class on all services conception rate in the 168 ewes present at lambing are shown in Table 4-31.

The logit models proved inappropriate for the analysis of this variable (Flock Model: error χ^2 = 48.113, 163 d.f.; Class Model: error χ^2 = 34.709, 155 d.f.).

The overall conception rate was 96.4%. There was only a negligible difference between Romney and BLX ewes. While all of the 43 ewes in Flock 2 lambed, 119 of the 125 (95.2%) in Flock 1 lambed. Of the six barren ewes, one was an Early Weaned ewe, two were Acyclic and the remaining three were Infertile ewes.

IV.5.5 Ovum Survival

Of the 164 ewes providing ovulation information, 141 lambed following first service matings. Five of these ewes lambed prematurely with no recording of the number of lambs born. It was assumed that the ovum survival rate (that is, the proportion of corpora lutea represented by lambs) was 100% for these three single and two twin ovulating ewes. Furthermore, the two triple ovulating ewes were considered as twin ovulators for the purposes of analysis.

TABLE 4-31 EFFECT OF BREED, FLOCK AND CLASS ON FIRST SERVICE AND ALL SERVICES CONCEPTION (ALL EWES)

Classification:		Ewes Conceiving (%)	
Breed of Ewe	No.	First Service	All Services
Romney	90	84.4	96.7
BLX	78	85.9	96.2
Flock			
Joined	125	82.4	95.2
Unjoined	43	93.0	100.0
Class			
1. Early Weaned	36	83.3	97.2
2. Late Weaned	38	81.6	100.0
3. Oestrous	41	92.7	100.0
4. Lamb Died	16	93.8	100.0
5. Acyclic	16	81.3	87.5
6. Infertile	21	76.2	85.7

Single Ovulators

Since the concept of ovum survival is synonymous with conception for single ovulating ewes, earlier results (Conception First Service - Single Ovulators) are directly applicable.

Multiple Ovulators - No Survival

Since the situation where no ova survive is synonymous with conception failure, results presented earlier (Conception First Service - Multiple Ovulators) could be adapted and applied to this section. Thus 7.7% of multiple ovulating ewes were barren.

Multiple Ovulators - Partial Survival

The effect of various factors on the incidence of multiple ovulating ewes giving birth to one lamb (also referred to as partial failure of multiple ovulation) are presented in Tables 4-32 and 4-33. The overall incidence was 26.2%.

There was a greater (N.S.) incidence of partial survival in Romney (36.0%) than BLX (20.0%) and Unjoined (29.4%) than Joined ewes (25.0%). Furthermore, although the incidence ranged from 13.3% (Early Weaned) to 42.9% (Lamb Died) for class of ewe, this was not a significant source of variation. Partial survival was independent of March 15 liveweight.

Multiple Ovulators - Total Survival

Breed, flock and class effects on the incidence of total ovum survival are found in Table 4-32. The analyses of variance are presented in Table 4-34. The mean incidence was 66.2%.

A larger proportion of BLX (75.0%) than Romney ewes (52.0%) gave birth to two lambs. The difference approached significance. There was very little difference between Joined and Unjoined ewes. The incidence varied from 55.6% (Infertile ewes) to 80.0% (Early Weaned ewes) for class of ewe. However, none of the class differences were significant.

All Corpora Lutea

Table 4-35 contains the effect of breed, flock and class on the proportion of all corpora lutea that were represented by lambs. The

TABLE 4-32 EFFECT OF BREED, FLOCK AND CLASS ON INCIDENCE OF PARTIAL AND TOTAL SURVIVAL OF MULTIPLE OVULATION

Classification:		Incidence (%)	
Breed of Ewe	No.	Partial Survival	Total Survival
Romney	25	36.0	52.0
BLX	40	20.0	75.0
Flock			
Joined	48	25.0	66.7
Unjoined	17	29.4	64.7
Class			
1. Early Weaned	15	13.3	80.0
2. Late Weaned	10	30.0	60.0
3. Oestrous	16	25.0	68.8
4. Lamb Died	7	42.9	57.1
5. Acyclic	8	25.0	62.5
6. Infertile	9	33.3	55.6

TABLE 4-33 EFFECT OF BREED, FLOCK, CLASS AND MARCH 15 LIVEWEIGHT ON INCIDENCE OF PARTIAL SURVIVAL OF MULTIPLE OVULATION

ANOVA

Source of Variation	d.f.	Deviance	Deviance
		Flock Model	Class Model
Breed	1	1.921	1.195
Flock	1	0.043	-
Class	5	-	1.890
Breed x Flock	1	1.576	-
Breed x Class	5	-	7.063
Regression on March 15 liveweight (Pooled within-classes)	1	0.342	0
Error		70.742 (60 df)	63.750 (52 df)
Total	64		

TABLE 4-34 EFFECT OF BREED, FLOCK, CLASS AND MARCH 15 LIVEWEIGHT ON INCIDENCE OF TOTAL SURVIVAL OF MULTIPLE OVULATION

ANOVA

Source of Variation	d.f.	Deviance	Deviance
		Flock Model	Class Model
Breed	1	3.579†	2.712†
Flock	1	0.003	-
Class	5	-	1.398
Breed x Flock	1	2.351	-
Breed x Class	5	-	10.527†
Regression on March 15 liveweight (pooled within-classes)	1	0.171	0.228
Error		77.079 (60 df)	67.451 (52 df)
Total	64		

analyses of variance are presented in Table 4-36. Overall, 80.3% of corpora lutea were represented by lambs.

The difference between BLX (82.6%) and Romney ewes (78.1%) was small. Joined ewes (78.7%) had a lower ovum survival rate than Unjoined ewes (85.0%). Neither of these differences were significant. Although ovum survival rates varied from 70.0% (Infertile ewes) to 86.0% (Oestrous ewes) none of the differences between classes were significant. Furthermore, ovum survival was independent of March 15 liveweight.

IV.5.6 Lambs Born Per Ewe

A total of 168 ewes were joined of which 143 lambed to first service matings. Five of these lambed prematurely, two of which were assumed to have borne twins. An additional 19 ewes lambed as a consequence of return to service matings. Four of these lambed prematurely. All four were assumed to have borne singles.

Lambing Ewes

The effect of breed, flock and class on the incidence of lambing ewes bearing twins are shown in Table 4-37. The analyses of variance are found in Tables 4-38 (first service) and 4-39 (all services).

Thirty percent and 27.2% of first service and all service ewes respectively gave birth to twins. Approximately 27% more cross-bred than straight-bred ewes gave birth to twins. This difference was highly significant ($P < 0.001$).

There was a small (~3%) twinning advantage to Joined over Unjoined ewes. However, this difference was not significant.

Class differences were not significant. However, about 10% more Early Weaned than Oestrous ewes twinned compared to about 10% fewer Late Weaned than Oestrous ewes. Furthermore, Late Weaned ewes had the lowest twinning rate.

TABLE 4-35 EFFECT OF BREED, FLOCK AND CLASS ON INCIDENCE OF OVUM SURVIVAL (ALL CORPORA LUTEA)

Classification:		No.	Incidence (%)
Breed of Ewe			
	Romney	114	78.1
	BLX	115	82.6
Flock			
	Joined	169	78.7
	Unjoined	60	85.0
Class			
1.	Early Weaned	49	83.7
2.	Late Weaned	47	78.7
3.	Oestrous	57	86.0
4.	Lamb Died	23	82.6
5.	Acyclic	23	73.9
6.	Infertile	30	70.0

TABLE 4-36 EFFECT OF BREED, FLOCK, CLASS AND MARCH 15 LIVEWEIGHT ON INCIDENCE OF OVUM SURVIVAL (ALL CORPORA LUTEA)

ANOVA

Source of Variation	d.f.	Deviance	Deviance
		Flock Model	Class Model
Breed	1	0.921	1.152
Flock	1	1.937	-
Class	5	-	2.547
Breed x Flock	1	1.441	-
Breed x Class	5	-	9.012
Regression on March 15 Liveweight (Pooled within-classes)	1	0.742	0.248
Error		234.731 (224 df)	229.111 (216 df)
Total	228		

TABLE 4-37 EFFECT OF BREED, FLOCK AND CLASS ON INCIDENCE OF TWINNING IN LAMBING EWES

Classification:		Incidence(%)		
Breed of Ewe	No.	First Service	No.	All Services
Romney	76	17.1	87	14.9
BLX	67	44.8	75	41.3
Flock				
Joined	103	31.1	119	27.7
Unjoined	40	27.5	43	25.6
Class				
1. Early Weaned	30	40.0	35	34.3
2. Late Weaned	31	19.4	38	15.8
3. Oestrous	38	28.9	41	26.8
4. Lamb Died	15	26.7	16	25.0
5. Acyclic	13	38.5	14	42.9
6. Infertile	16	31.3	18	27.7

TABLE 4-38 EFFECT OF BREED, FLOCK, CLASS AND MARCH 15 LIVEWEIGHT ON INCIDENCE OF TWINNING IN LAMBING EWES (FIRST SERVICE)

ANOVA

Source of Variation	d.f.	Deviance	Deviance
		Flock Model	Class Model
Breed	1	13.224***	14.057***
Flock	1	0.221	-
Class	5	-	4.588
Breed x Flock	1	0.023	-
Breed x Class	5	-	4.264
Regression on March 15 liveweight (Pooled within-classes)	1	4.983*	5.012*
Error		156.470 (138 df)	147.833 (130 df)
Total	142		

TABLE 4-39 EFFECT OF BREED, FLOCK, CLASS AND MARCH 15 LIVEWEIGHT ON INCIDENCE OF TWINNING IN LAMBING EWES (ALL SERVICES)

ANOVA

Source of Variation	d.f.	Deviance	Deviance
		Flock Model	Class Model
Breed	1	11.957***	14.429***
Flock	1	0.005	-
Class	5	-	5.405
Breed x Flock	1	0.107	-
Breed x Class	5	-	5.654
Regression on March 15 liveweight (Pooled within-classes)	1	5.178*	5.581*
Error		168.173 (157 df)	157.690 (149 df)
Total	161		

The regression on March 15 liveweight was significant ($P < 0.05$). The pooled within-classes odds ratio multiplicative factors were, for first service ewes, 1.080 (Flock Model) and 1.094 (Class Model) and for all service ewes, 1.078 (Flock Model) and 1.099 (Class Model). Figure 4-12 illustrates the relationship between twinning and liveweight (first service ewes, Class Model). Since the three remaining relationships are similar, they have been omitted.

Joined Ewes - One Lamb

Table 4-40 contains the effect of breed, flock and class on the proportion of joined ewes giving birth to one lamb. The analyses of variance are found in Tables 4-41 and 4-42 for first service and all services respectively.

The incidence of joined ewes giving birth to one lamb was 59.5% and 70.2% following first service and all services respectively. Approximately 24% more Romney than BLX ewes gave birth to singles (First service: $P < 0.05$ Flock Model; $P < 0.01$, Class Model; All services, $P < 0.001$).

Although 10.6% and 5.6% more Unjoined than Joined ewes gave birth to singles following first service and all services respectively, neither of the differences was significant.

Although Class means ranged from 50% (Early Weaned, Acyclic) to 68.8% (Lamb Died), this was not a significant source of variation amongst first service ewes. Approximately 60% of Late Weaned and Oestrous ewes gave birth to singles. Class means ranged from 50.0% (Acyclic) to 84.2% (Late Weaned) for all service ewes. However, Class differences approached significance. Approximately 9% more Oestrous than Late Weaned ewes gave birth to singles.

While the regression on March 15 liveweight was not significant for first service ewes, it was a significant source of variation for all

FIGURE 4-12 : REGRESSION OF INCIDENCE OF TWINNING PER EWE LAMBING TO FIRST SERVICE (P) ON MARCH 15 LIVEWEIGHT (LW) (CLASS MODEL)

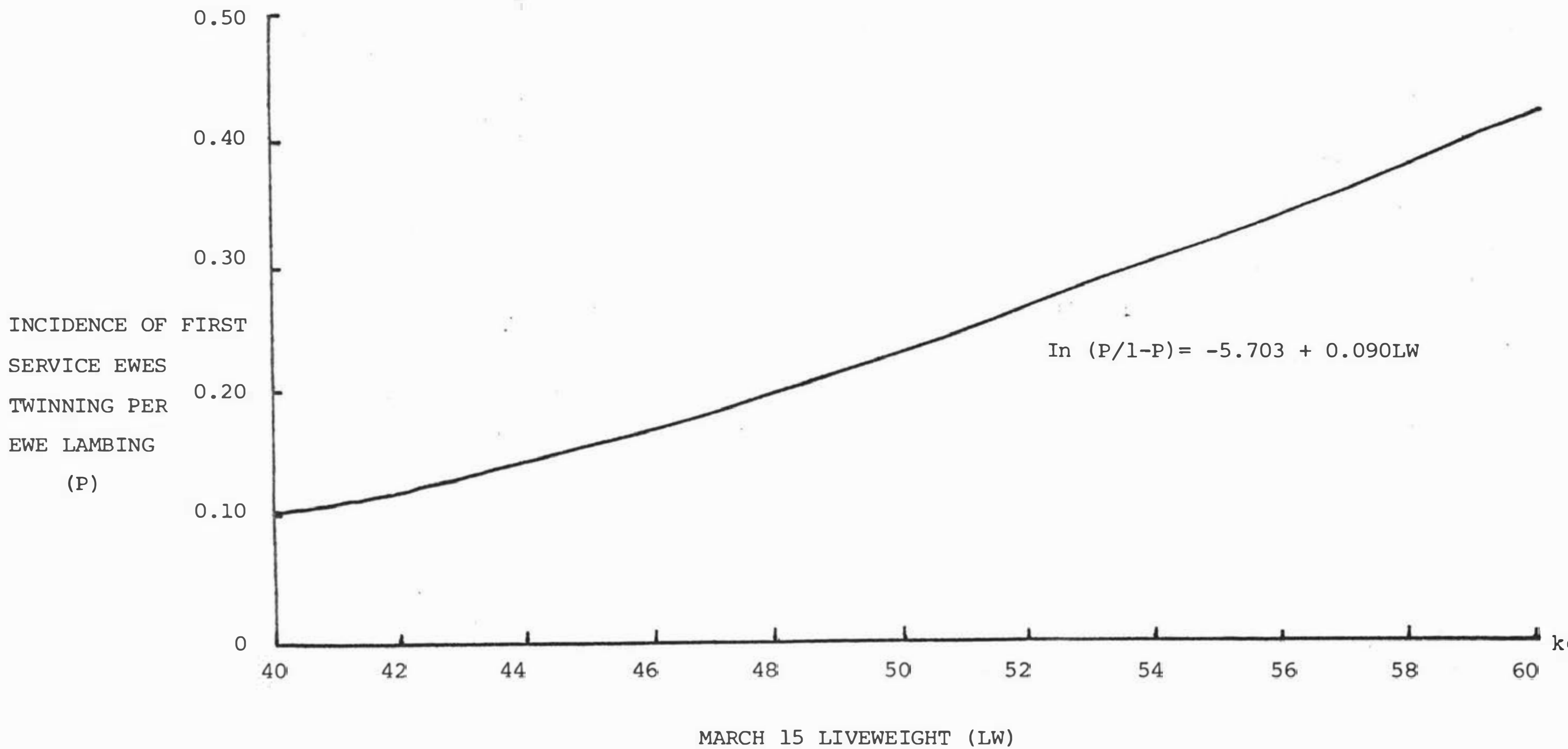


TABLE 4-40 EFFECT OF BREED, FLOCK AND CLASS ON INCIDENCE OF SINGLE BIRTHS IN JOINED EWES

Classification:		Incidence (%)	
Breed of Ewe	No.	First Service	All Services
Romney	90	70.0	82.2
BLX	78	47.4	56.4
Flock			
Joined	125	56.8	68.8
Unjoined	43	67.4	74.4
Class			
1. Early Weaned	36	50.0	63.9
2. Late Weaned	38	65.8	84.2
3. Oestrous	41	65.9	73.2
4. Lamb Died	16	68.8	75.0
5. Acyclic	16	50.0	50.0
6. Infertile	21	52.4	61.9

TABLE 4-41 EFFECT OF BREED, FLOCK, CLASS AND MARCH 15 LIVEWEIGHT ON INCIDENCE OF SINGLE BIRTHS IN JOINED EWES (FIRST SERVICE)

ANOVA

Source of Variation	d.f.	Deviance	Deviance
		Flock Model	Class Model
Breed	1	8.004*	8.565**
Flock	1	1.385	-
Class	5	-	5.532
Breed x Flock	1	0.087	-
Breed x Class	5	-	1.147
Regression on March 15 liveweight (Pooled within-classes)	1	2.168	2.040
Error		214.395 (163 df)	209.316 (155 df)
Total	167		

TABLE 4-42 EFFECT OF BREED, FLOCK, CLASS AND MARCH 15 LIVEWEIGHT ON INCIDENCE OF SINGLE BIRTHS IN JOINED EWES (ALL SERVICES)

ANOVA

Source of Variation	d.f.	Deviance	Deviance
		Flock Model	Class Model
Breed	1	13.528***	16.178***
Flock	1	0.540	-
Class	5	-	10.252†
Breed x Flock	1	0.102	-
Breed x Class	5	-	2.467
Regression on March 15 liveweight (Pooled within-classes)	1	6.975**	5.325*
Error		183.470 (163 df)	172.043 (155 df)
Total	167		

services ewes (Flock Model, $P \leq 0.01$; Class Model, $P \leq 0.05$). The respective odds ratio multiplicative factors were 0.919 and 0.916 per kg increase in March 15 liveweight. The relationship is illustrated in Figure 4-13 (Flock Model). Increasing March 15 liveweight was associated with a decreasing incidence of ewes lambing singles.

Joined Ewes - Two Lambs

The effect of breed, flock and class on the proportion of joined ewes giving birth to twins are found in Table 4-43 and the analyses of variance in Table 4-44. No analysis of twinning was carried out for all services data as only one ewe that returned to service gave birth to twins.

Approximately 25% more BLX than Romney ewes gave birth to twins. The difference was highly significant ($P < 0.001$).

The incidence of twinning in Joined and Unjoined ewes was very similar. Furthermore, Class of ewe was not a significant source of variation. The incidence of twinning was the least for Late Weaned ewes (15.8%), intermediate for Oestrous ewes (26.8%) and slightly higher for Early Weaned ewes (33.3%).

The pooled within-classes regression on March 15 liveweight was significant ($P < 0.05$). The odds ratio multiplicative factors were 1.081 and 1.101 for the Flock and Class Models respectively. This is illustrated in Figure 4-14 (Flock Model). Increasing March 15 liveweight was associated with an increasing incidence of twinning.

IV.5.7 Lambs Weaned Per Ewe

Some of the factors affecting the proportion of lambing and joined ewes weaning zero, one or two lambs following all services, were investigated. Of the 168 ewes present at joining and lambing, 166 were present at weaning.

FIGURE 4-13 : REGRESSION OF INCIDENCE OF JOINED EWES LAMBING SINGLES (P) ON MARCH 15 LIVEWEIGHT (LW) (ALL SERVICES - FLOCK MODEL)

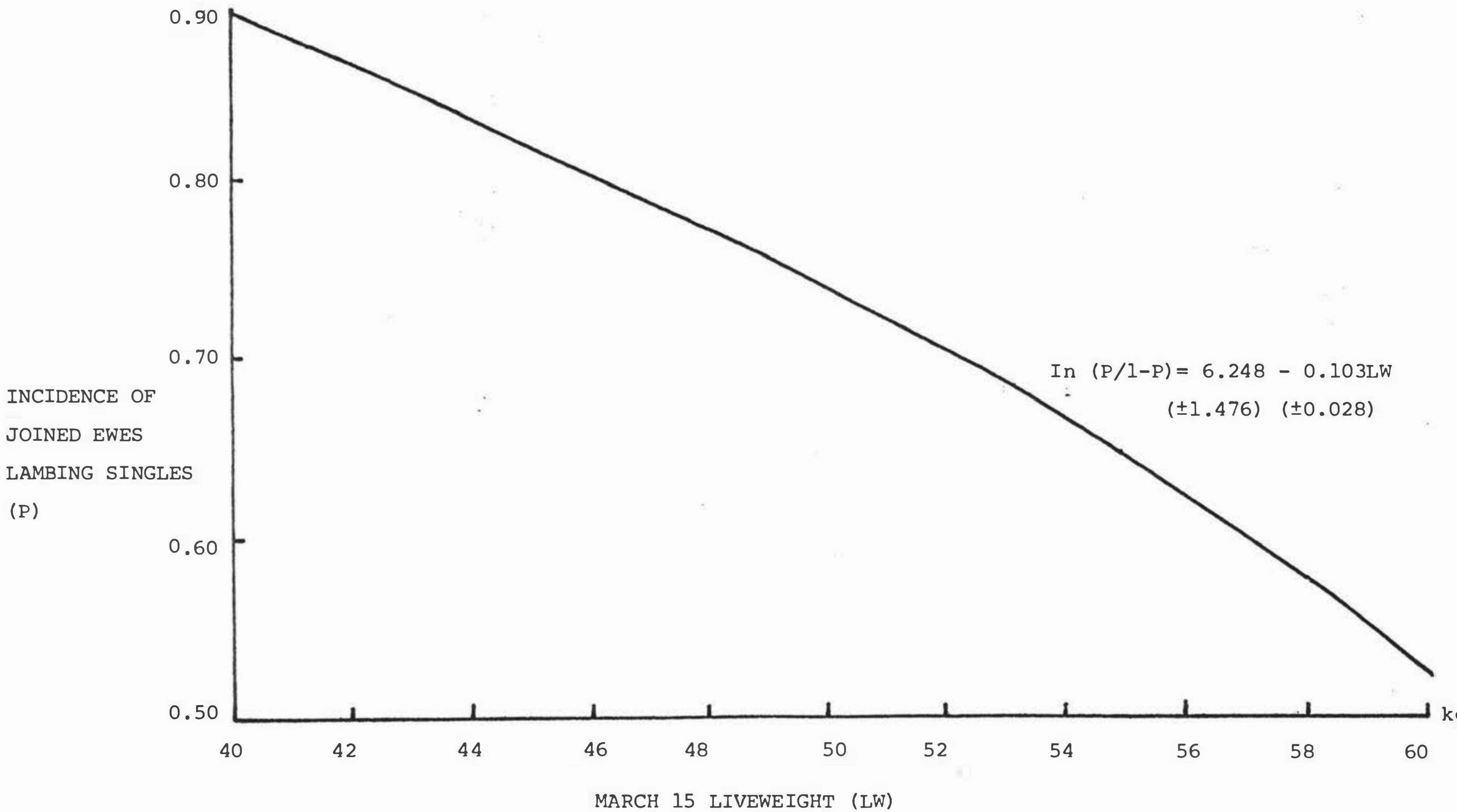


TABLE 4-43 EFFECT OF BREED, FLOCK AND CLASS ON PROPORTION OF JOINED EWES TWINNING

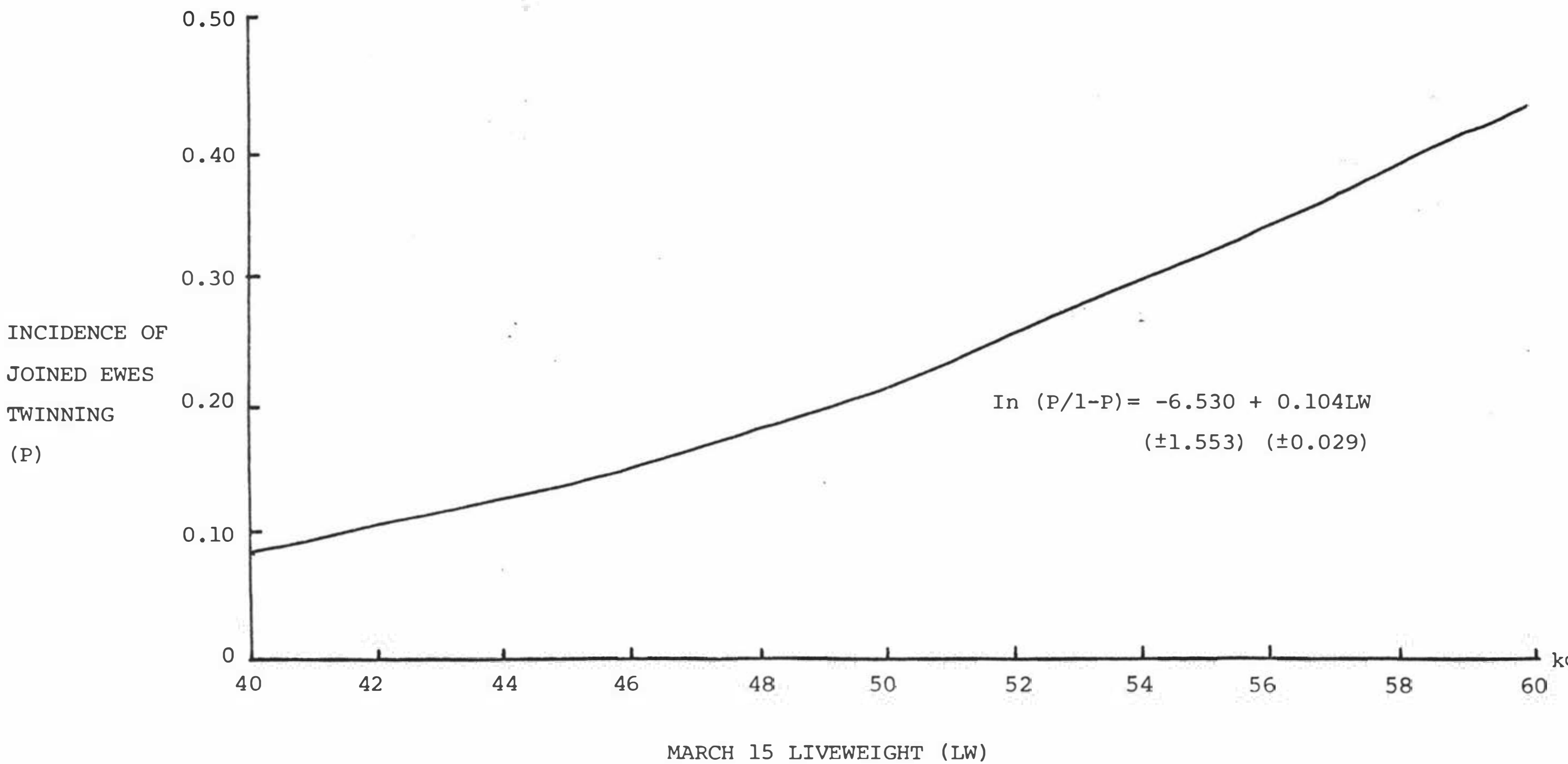
Classification:	No.	Incidence (%) First Service	Incidence (%) All Services
Breed of Ewe			
Romney	90	14.4	14.4
BLX	78	38.5	39.7
Flock			
Joined	125	25.6	26.4
Unjoined	43	25.6	25.6
Class			
1. Early Weaned	36	33.3	33.3
2. Late Weaned	38	15.8	15.8
3. Oestrous	41	26.8	26.8
4. Lamb Died	16	25.0	25.0
5. Acyclic	16	31.3	37.5
6. Infertile	21	23.8	23.8

TABLE 4-44 EFFECT OF BREED, FLOCK, CLASS AND MARCH 15 LIVEWEIGHT ON INCIDENCE OF TWINNING IN JOINED EWES (FIRST SERVICE)

ANOVA

Source of Variation	d.f.	Deviance	Deviance
		Flock Model	Class Model
Breed	1	12.840***	13.618***
Flock	1	0	-
Class	5	-	4.301
Breed x Flock	1	0.076	-
Breed x Class	5	-	6.326
Regression on March 15 liveweight (Pooled within-classes)	1	5.547*	5.860*
Error		172.647 (163 df)	161.783 (155 df)
Total	167		

FIGURE 4-14 : REGRESSION OF INCIDENCE OF JOINED EWES TWINNING (P) ON MARCH 15 LIVEWEIGHT (LW) (FIRST SERVICE - FLOCK MODEL)



Lambing Ewes

The mean incidences of ewes weaning zero, one or two lambs are presented in Table 4-45.

No Lambs Weaned

The logit model proved inappropriate for the Flock (error χ^2 = 153.504, 157 d.f.) and Class Models (error χ^2 = 147.758, 149 d.f.). However, when the covariate (March 15 liveweight) was removed from the Class Model, error χ^2 exceeded error d.f. (Table 4-46).

Although more Romney than BLX and Unjoined than Joined ewes failed to wean any lambs, neither of the differences were significant. Class of ewe was not a significant source of variation. Ewes that had previously weaned lambs were more likely to wean lambs as two-year-olds.

One Lamb Weaned

The analysis of variance of ewes weaning one lamb is found in Table 4-47. Approximately 12% more Romney than BLX ewes weaned one lamb ($P < 0.1$, Class Model). More Joined than Unjoined ewes weaned one lamb (N.S.). Class of ewe differences were not significant. However, approximately 14% more Late Weaned than Early Weaned or Oestrous ewes weaned only one lamb.

Two Lambs Weaned

The logit model was inappropriate for explaining variation in the incidence of ewes weaning twins (Flock Model: error χ^2 = 142.545, 157 d.f.; Class Model: error χ^2 = 137.234, 149 d.f.).

There was a 28% incidence of BLX ewes weaning twins compared to only 10.3% for Romneys. A similar proportion of Joined and Unjoined ewes weaned twins. Class of ewe means ranged from 10.5% (Late Weaned) to 28.6% (Early Weaned, Acyclic). Oestrous ewes were intermediate at 17.1%.

Total Number of Lambs Weaned

The mean ratio of lambs weaned per ewe lambing was 0.99. BLX ewes

TABLE 4-45 EFFECT OF BREED, FLOCK AND CLASS ON INCIDENCE OF LAMBING EWES WEANING ZERO, ONE, OR TWO LAMBS (ALL SERVICES)

Classification		Incidence (%)			
		Lambs Weaned Per Ewe			
Breed of Ewe	No.	Zero	One	Two	LW/EL[A]
Romney	87	21.8	67.8	10.3	0.89
BLX	75	16.0	56.0	28.0	1.12
Flock					
Joined	119	16.8	63.9	19.3	1.03
Unjoined	43	25.6	58.1	16.3	0.91
Class					
1. Early Weaned	35	11.4	60.0	28.6	1.17
2. Late Weaned	38	15.8	73.7	10.5	0.95
3. Oestrous	41	24.4	58.5	17.1	0.93
4. Lamb Died	16	18.7	68.8	12.5	0.94
5. Acyclic	14	21.4	50.0	28.6	1.07
6. Infertile	18	27.8	55.6	16.7	0.89

A Lambs Weaned Per Ewe Lambing

TABLE 4-46 EFFECT OF BREED AND CLASS ON INCIDENCE OF LAMBING EWES WEANING NO LAMBS (ALL SERVICES)

ANOVA

Source of Variation	d.f.	Deviance
		Class Model
Breed	1	0.566
Class	5	3.003
Breed x Class	5	3.167
Error	150	151.107
Total	161	

TABLE 4-47 EFFECT OF BREED, FLOCK, CLASS AND MARCH 15 LIVEWEIGHT ON INCIDENCE OF LAMBING EWES WEANING ONE LAMB (ALL SERVICES)

ANOVA

Source of Variation	d.f.	Deviance	Deviance
		Flock Model	Class Model
Breed	1	2.397	3.037†
Flock	1	0.439	-
Class	5	-	4.679
Breed x Flock	1	0.054	-
Breed x Class	5	-	0.693
Regression on March 15 liveweight (Pooled within-classes)	1	0.209	0.002
Error		211.503 (157 df)	206.831 (149 df)
Total	161		

weaned 0.23 more lambs per ewe lambing than Romney ewes. The advantage to Joined over Unjoined ewes was 0.12 lambs. Class of ewe means ranged from 0.89 (Infertile) to 1.17 (Early Weaned). There was only a small difference between Late Weaned and Oestrous ewes.

Joined Ewes

The mean incidences of ewes weaning zero, one or two lambs are presented in Table 4-48.

No Lambs Weaned

The effect of breed, flock, class and March 15 liveweight are shown in Table 4-49.

Although approximately 5% more Romney than BLX and Unjoined than Joined ewes failed to wean any lambs, neither of the differences were significant. Furthermore, Class of ewe was not a significant source of variation. However, a greater proportion of Oestrous compared to Early Weaned and Late Weaned ewes failed to wean any lambs.

The regression on March 15 liveweight was not significant for either model.

One Lamb Weaned

The analysis of variance is presented in Table 4-50. More Romney than BLX ewes were likely to wean one lamb ($P < 0.1$, Class Model). The difference between Joined and Unjoined ewes was very small. Class differences were not significant. While a similar proportion of Early Weaned and Oestrous ewes weaned one lamb, approximately 16% more Late Weaned ewes weaned only one lamb.

The regression on March 15 liveweight was not significant.

Two Lambs Weaned

The logit model proved inappropriate for the analysis of this variable (Flock Model: error χ^2 = 147.184, 163 d.f.; Class Model:

TABLE 4-48 EFFECT OF BREED, FLOCK AND CLASS ON INCIDENCE OF JOINED EWES WEANING ZERO, ONE OR TWO LAMBS (ALL SERVICES)

Classification:		Incidence (%)			
		Lambs Weaned Per Ewe			
Breed of Ewe	No.	Zero	One	Two	LW/EJ[A]
Romney	90	24.4	65.6	10.0	0.86
BLX	78	19.2	53.8	26.9	1.08
Flock					
Joined	125	20.8	60.8	18.4	0.98
Unjoined	43	25.6	58.1	16.3	0.91
Class					
1. Early Weaned	36	13.9	58.3	27.8	1.14
2. Late Weaned	38	15.8	73.7	10.5	0.95
3. Oestrous	41	24.4	58.5	17.1	0.93
4. Lamb Died	16	18.7	68.8	12.5	0.94
5. Acyclic	16	31.3	43.7	25.0	0.94
6. Infertile	21	38.1	47.6	14.3	0.76

A Lambs Weaned per Ewe Joined

TABLE 4-49 EFFECT OF BREED, FLOCK, CLASS AND MARCH 15 LIVEWEIGHT ON INCIDENCE OF JOINED EWES WEANING NO LAMBS (ALL SERVICES)

ANOVA

Source of Variation	d.f.	Deviance	Deviance
		Flock Model	Class Model
Breed	1	0.668	0.325
Flock	1	0.419	-
Class	5	-	5.860
Breed x Flock	1	0.178	-
Breed x Class	5	-	3.861
Regression on March 15 liveweight (Pooled within-classes)	1	1.744	1.125
Error		174.136 (163 df)	162.631 (155 df)
Total	167		

TABLE 4-50 EFFECT OF BREED, FLOCK, CLASS AND MARCH 15 LIVEWEIGHT ON INCIDENCE OF JOINED EWES WEANING ONE LAMB (ALL SERVICES)

	ANOVA		
Source of Variation	d.f.	Deviance	Deviance
		Flock Model	Class Model
Breed	1	2.391	3.216†
Flock	1	0.094	-
Class	5	-	7.584
Breed x Flock	1	0.067	-
Breed x Class	5	-	0.644
Regression on March 15 liveweight (Pooled within-classes)	1	0.178	0.050
Error		223.239 (163 df)	215.300 (155 df)
Total	167		

error χ^2 = 141.936, 155 d.f.).

Almost 27% of BLX ewes weaned twins compared to only 10% of Romneys. Slightly more Unjoined (18.6%) than Joined ewes (18.4%) weaned twins. Class of ewe means ranged from 10.5% (Late Weaned) to 27.8% (Early Weaned). Oestrous ewes, at 17.0%, were intermediate.

Total Number of Lambs Weaned

The ratio of lambs weaned per ewe joined takes account of ewe fertility, ewe litter size and lamb survival to weaning. BLX ewes weaned 0.22 more lambs per ewe joined than Romney ewes while Flock 1 ewes weaned 0.07 less lambs than Flock 2 ewes. Early Weaned ewes weaned 0.19 and 0.21 more lambs per ewe joined than Late Weaned and Oestrous ewes respectively. The lowest ratio was for Infertile ewes (0.76 lambs weaned per ewe joined).

IV.5.8 Fleece Production

Studies were carried out on factors affecting fleece weight prior to two-year-old mating (February Fleece Weight) and at two-year-old weaning (November Fleece Weight). In addition, the total weight of fleece from these two shearings along with that produced to September 1977 were analysed (Cumulative fleece weight). There were 166 ewes present at all shearings (see Table 4-1).

The effect of breed, birth rank and flock on February, November and Cumulative fleece production are presented in Tables 4-51 and 4-52. Tables 4-53, 4-54 and 4-55 contain the effect of breed and class on February, November and Cumulative fleece production respectively.

February Fleece Weight

Flock Model

Cross-bred ewes produced 0.22 kg more than Romney ewes ($P < 0.001$). The 0.29 kg in favour of Unjoined over Joined ewes was also highly

TABLE 4-51 EFFECT OF BREED, BIRTH RANK AND FLOCK ON FLEECE WEIGHT (FEBRUARY, NOVEMBER AND CUMULATIVE)

Classifcation:	Fleece Weight (kg) (Mean ± S.E.)		
Breed of Ewe	February	November	Cumulative
Romney	2.64 ± 0.07	3.14 ± 0.07	8.97 ± 0.18
BLX	2.86 ± 0.05	3.45 ± 0.05	9.95 ± 0.13
Birth Rank			
Single	2.76 ± 0.07	3.28 ± 0.07	9.46 ± 0.20
Twin	2.73 ± 0.05	3.28 ± 0.05	9.38 ± 0.15
Flock			
Joined	2.67 ± 0.08	3.27 ± 0.08	9.33 ± 0.22
Unjoined	2.96 ± 0.07	3.30 ± 0.07	9.70 ± 0.19

TABLE 4-52 EFFECT OF BREED, BIRTH RANK AND FLOCK ON FLEECE WEIGHT (FEBRUARY, NOVEMBER AND CUMULATIVE)

ANOVA

Source of Variation	d.f.	Mean Square		
		February	November	Cumulative
Breed	1	1.79***	3.91***	39.5***
Birth Rank	1	0	0	0.12
Flock	1	2.61***	0.02	3.81†
Breed x Birth Rank	1	0.08	0.39	1.00
Breed x Flock	1	0.08	0.44	1.68
Birth Rank x Flock	1	0.07	0	0.01
Breed x Birth Rank x Flock	1	0.09	0.06	0.02
Error	158	0.175	0.193	1.350
Total	165			

TABLE 4-53 EFFECT OF BREED AND CLASS ON TWO-YEAR-OLD EWE FEBRUARY FLEECE WEIGHT

Classification:	Fleece Weight (kg) (Mean ± S.E.)		
Class	Breed of Ewe		
	Romney	BLX	Both Breeds
1. Early Weaned	2.41 ± 0.17a	2.79 ± 0.17a	2.62 ± 0.11
2. Late Weaned	2.38 ± 0.17a	2.56 ± 0.17b	2.48 ± 0.11
3. Oestrous	2.90 ± 0.17b	3.05 ± 0.17cd	2.97 ± 0.11
4. Lamb Died	2.93 ± 0.19b	2.87 ± 0.21abc	2.91 ± 0.14
5. Acyclic	2.57 ± 0.19ac	3.32 ± 0.21d	2.85 ± 0.14
6. Infertile	2.72 ± 0.18bc	2.91 ± 0.14ac	2.79 ± 0.09
All Classes	2.64 ± 0.07	2.86 ± 0.05	

ANOVA

Source of Variation	d.f.	Mean Square
Breed	1	2.55***
Class	5	1.32***
Breed x Class	5	0.32*
Error	154	0.145
Total	165	

TABLE 4-54 EFFECT OF BREED AND CLASS ON TWO-YEAR-OLD EWE NOVEMBER FLEECE WEIGHT

Classification:	Fleece Weight (kg) (Mean ± S.E.)
Breed of Ewe	
Romney	3.14 ± 0.07
BLX	3.45 ± 0.05
Class	
1. Early Weaned	3.23 ± 0.13
2. Late Weaned	3.21 ± 0.12
3. Oestrous	3.33 ± 0.12
4. Lamb Died	3.27 ± 0.15
5. Acyclic	3.21 ± 0.15
6. Infertile	3.46 ± 0.10

ANOVA

Source of Variation	d.f.	Mean Square
Breed	1	4.44***
Class	5	0.316
Breed x Class	5	0.33†
Error	154	0.182
Total	165	

TABLE 4-55 EFFECT OF BREED AND CLASS ON TWO-YEAR-OLD EWE CUMULATIVE FLEECE WEIGHT

Classification:	Fleece Weight (kg) (Mean ± S.E.)		
Class	Breed of Ewe		
	Romney	BLX	Both Breeds
1. Early Weaned	8.28 ± 0.50a	10.11 ± 0.49a	9.27 ± 0.34
2. Late Weaned	8.74 ± 0.49ac	9.41 ± 0.48b	0.09 ± 0.34
3. Oestrous	9.47 ± 0.48b	10.12 ± 0.49ab	9.78 ± 0.33
4. Lamb Died	9.57 ± 0.54b	9.77 ± 0.61ab	9.64 ± 0.41
5. Acyclic	8.31 ± 0.54a	10.43 ± 0.61a	9.11 ± 0.41
6. Infertile	9.33 ± 0.51bc	10.36 ± 0.43a	9.67 ± 0.27
All Classes	8.97 ± 0.18	9.95 ± 0.13	

ANOVA

Source of Variation	d.f.	Mean Square
Breed	1	44.04***
Class	5	3.59*
Breed x Class	5	3.07*
Error	154	1.212
Total	165	

significant ($P < 0.001$). However, ewe birth rank had a very small influence on fleece weight.

Class Model

Since the breed by class interaction was significant ($P < 0.05$) the results are presented separately for each breed. Breed differences, within each class, have also been tested.

Romney Ewes

Late Weaned ewes (2.38 kg) produced the lightest fleeces. However, they were not significantly lighter than fleeces produced by Early Weaned (2.41 kg) or Acyclic ewes (2.57 kg). Ewes in these three classes produced significantly lighter fleeces than Infertile (2.72 kg), Oestrous (2.90 kg) and Lamb Died ewes (2.93 kg). Ewes in the latter three classes produced fleeces that were not significantly different from each other. Finally, the difference between Acyclic and Infertile ewes was not significant.

BLX Ewes

Late Weaned ewes (2.56 kg) produced the lightest fleeces. These were significantly lighter than all classes except Lamb Died ewes (2.87 kg). Early Weaned ewes (2.79 kg) produced fleeces that were lighter (N.S.) than Lamb Died and Infertile ewe fleece weights (2.91 kg). However, they were significantly lighter than fleeces produced by Oestrous (3.05 kg) and Acyclic ewes (3.32 kg).

Breed Effect

With the exception of Lamb Died ewes, BLX ewes produced heavier fleeces than Romney ewes. However, only the differences for Early Weaned (0.38 kg) and Acyclic ewes (0.75 kg) were significant.

November Fleece Weight

Flock Model

BLX ewes produced 0.31 kg more fleece weight than Romney ewes ($P < 0.001$)

However, there was very little difference between Joined and Unjoined ewes. Single- and twin-born ewes produced identical fleece weights.

Class Model

Late Weaned and Acyclic ewes (3.21 kg) clipped the lightest fleeces. The remaining classes ranked in ascending order were: Early Weaned (3.23 kg), Lamb Died (3.27 kg), Oestrous (3.33 kg) and Infertile (3.46 kg). Class, however, was not a significant source of variation.

The breed by class interaction approached significance.

Cumulative Fleece Weight

Flock Model

When aggregated over the three shearings, BLX ewes grew almost 1 kg more wool than Romney ewes ($P < 0.001$). The 0.37 kg advantage to Unjoined over Joined ewes approached significance. There was only a minor difference between single- and twin-born ewes.

Class Model

The results are presented separately for each breed since the breed by class interaction was significant ($P < 0.05$). Breed differences, within each class, have also been tested.

Romney Ewes

Early Weaned ewes (8.28 kg) produced the lightest weight of fleece. However, they were not significantly lighter than fleeces produced by Acyclic (8.31 kg) and Late Weaned ewes (8.74 kg). Ewes in these three classes, with one exception, produced significantly lighter fleeces than Infertile (9.33 kg), Oestrous (9.47 kg) and Lamb Died ewes (9.57 kg). There was no significant difference between Late Weaned and Infertile ewes. Furthermore, none of the differences between Infertile, Oestrous and Lamb Died ewes were significant.

BLX Ewes

Early Weaned ewes (10.11 kg) produced significantly more wool than

Late Weaned ewes (9.41 kg). Futhermore, Late Weaned ewes produced significantly less wool than Acyclic (10.43 kg) and Infertile ewes (10.36 kg). Oestrous (10.12 kg) and Lamb Died ewes (9.77 kg) clipped less wool than the latter two classes.

Breed Effect

BLX ewes produced more wool than Romney ewes of the same class. However, only the Early Weaned (1.83 kg) and Acyclic ewe (2.12 kg) differences were significant. The breed effect was 1.03 kg for Infertile ewes.

IV.6 Two-Year-Old Progeny Performance

Analyses were carried out on pre and postnatal growth as well as survival to weaning. One hundred and ninety five lambs were recorded at birth. In addition, an unknown number of lambs were unrecorded at birth due to late pregnancy abortions caused by Camplyobacter sp. infection (formerly known as Vibrio foetus).

IV.6.1 Prenatal Growth

Studies were carried out on the effect of breed, flock, sex, birth rank and class on lamb birth weight, gestation length and birth date.

Birth Weight

The effect of breed of dam, sex of lamb, flock and class of dam and lamb birth rank on birth weight are presented in Table 4-56. Analyses of variance are found in Tables 4-57, 4-58, 4-59 and 4-60.

Single-born Lambs

The mean birth weight of single-born lambs was 4.47 kg. Lambs born to Romney and BLX dams were of similar birth weight. Male lambs (4.60 kg) were heavier than female lambs (4.29 kg). This difference was significant ($P < 0.05$) for the Flock Model but only approached significance for the

TABLE 4-56 EFFECT OF BREED, FLOCK, SEX, BIRTH RANK AND CLASS ON BIRTH WEIGHT

Classification:		Birth Weight (kg) (Mean ± S.E.)				
	No.	Singles	No.	Twins	No.	All Lambs
Breed of Ewe						
Romney	71	4.46 ± 0.16	26	3.44 ± 0.14	97	4.19 ± 0.12
BLX	40	4.48 ± 0.12	58	3.86 ± 0.08	98	4.11 ± 0.08
Sex						
Male	65	4.60 ± 0.15	46	3.73 ± 0.14	111	4.23 ± 0.12
Female	46	4.29 ± 0.11	38	3.72 ± 0.11	84	4.04 ± 0.09
Flock						
Joined	79	4.48 ± 0.16	64	3.70 ± 0.17	143	4.13 ± 0.13
Unjoined	32	4.43 ± 0.14	20	3.83 ± 0.14	52	4.20 ± 0.11
Class						
1. Weaned	50	4.52 ± 0.24	34	3.79 ± 0.23	84	4.22 ± 0.19
2. Oestrous	30	4.41 ± 0.26	20	3.83 ± 0.25	50	4.18 ± 0.20
3. Lamb Died	10	4.45 ± 0.33	8	4.00 ± 0.30	18	4.25 ± 0.25
4. Acyclic	8	4.05 ± 0.35	12	3.49 ± 0.30	20	3.72 ± 0.25
5. Infertile	13	4.68 ± 0.22	10	3.40 ± 0.20	23	4.12 ± 0.17
Birth Rank	111	4.47 ± 0.11	84	3.73 ± 0.08		

TABLE 4-57 EFFECT OF BREED, SEX AND FLOCK ON BIRTH WEIGHT (SINGLE- AND TWIN-BORN LAMBS)

ANOVA

Source of Variation	d.f.	Mean Square	
		Single-born lambs	Twin-born lambs
Breed	1	0.008	3.09**
Sex	1	2.519*	0.025
Flock	1	0.023	0.263
Breed x Sex	1	0.512	0.722
Breed x Flock	1	0.001	0.220
Sex x Flock	1	0.125	0.154
Breed x Sex x Flock	1	0.583	0.462
Error		0.620 (103 df)	0.393 (76 df)
Total		(110 df)	(83 df)

TABLE 4-58 EFFECT OF BREED, SEX AND CLASS ON BIRTH WEIGHT (SINGLE- AND TWIN-BORN LAMBS)

ANOVA

Source of Variation	d.f.	Mean Square	
		Single-born lambs	Twin-born lambs
Breed	1	0.015	20.093***
Sex	1	2.268†	0.012
Class	4	0.470	0.415
Breed x Sex	1	0.632	0.113
Breed x Class	4	0.149	0.103
Sex x Class	4	0.161	0.480
Breed x Sex x Class	4	0.329	0.176
Error		0.659 (91 df)	0.403 (64 df)
Total		(110 df)	(83 df)

TABLE 4-59 EFFECT OF BREED, BIRTH RANK, SEX AND FLOCK ON BIRTH WEIGHT (ALL LAMBS).

ANOVA

Source of Variation	d.f.	Mean Square
Breed	1	1.303
Birth Rank	1	26.583***
Sex	1	1.435†
Flock	1	0.011
Breed x Birth Rank	1	1.686†
Breed x Sex	1	0.002
Breed x Flock	1	0.038
Birth Rank x Sex	1	1.210
Birth Rank x Flock	1	0.167
Sex x Flock	1	0.002
Error	184	0.523
Total	194	

TABLE 4-60 EFFECT OF BREED, BIRTH RANK, SEX AND CLASS ON BIRTH WEIGHT (ALL LAMBS)

ANOVA

Source of Variation	d.f.	Mean Square
Breed	1	0.855
Birth Rank	1	23.846***
Sex	1	1.525†
Class	4	0.509
Breed x Birth Rank	1	1.034
Breed x Sex	1	0.039
Breed x Class	4	0.080
Birth Rank x Sex	1	1.175
Birth Rank x Class	4	0.436
Sex x Class	4	0.145
Error	172	0.535
Total	194	

Class Model. Lambs born to ewes in Flock 1 and 2 were of similar birth weight. Infertile ewes (4.68 kg) gave birth to the heaviest lambs while Acyclic ewes (4.05 kg) gave birth to the lightest lambs. However, class differences were not significant.

Twin-born lambs

The mean birth weight of twin-born lambs was 3.73 kg. The progeny of BLX dams (3.86 kg) were significantly heavier (Flock Model, $P < 0.01$; Class Model, $P < 0.001$) than the progeny of Romney dams (3.44 kg). The difference between male and female lambs was negligible. Twin lambs born to Joined ewes were 0.13 kg lighter than those born to Unjoined ewes (N.S.). Class of ewe mean birth weights ranged from 3.40 kg (Infertile) to 4.00 kg (Lamb Died) but were not significantly different from each other.

All Lambs

The difference between the birth weight of lambs born to cross-bred and straight-bred ewes was negligible. Male lambs (4.23 kg) were heavier than female lambs (4.04 kg) at birth ($P < 0.1$). Lambs born to Unjoined ewes (4.20 kg) were heavier (N.S.) than lambs born to Joined ewes (4.13 kg). Although Class of ewe mean birth weights ranged from 3.72 kg (Acyclic) to 4.25 kg (Lamb Died), this was not a significant source of variation. Single-born lambs (4.47 kg) were significantly heavier ($P < 0.001$) than twin-born lambs (3.73 kg). However, there was some suggestion of an interaction with breed of dam ($P < 0.1$, Flock Model only). Thus, there was a larger birth rank effect in Romney (1.02 kg) than BLX ewes (0.62 kg).

Gestation Length

Table 4-61 contains the mean gestation lengths for the various factors. The analyses of variance are found in Tables 4-62, 4-63, 4-64 and 4-65.

Single-born Lambs

BLX lambs (146.5 days) remained <u>in utero</u> for one day more ($P < 0.05$) than Romney lambs (145.5 days). There was little difference between male

TABLE 4-61 EFFECT OF BREED, FLOCK, SEX, CLASS AND BIRTH RANK ON GESTATION LENGTH

Classification:	Gestation Length (days)					
	No.	Singles	No.	Twin Sets	No.	All Lambs
Breed of Ewe				(Mean ± S.E.)		
Romney	71	145.5 ± 0.5	13	145.0 ± 1.1	84	145.4 ± 0.5
BLX	40	146.5 ± 0.4	29	146.0 ± 0.6	69	146.3 ± 0.3
Sex						
Male	65	146.0 ± 0.5	9	145.9 ± 1.3	74	146.0 ± 0.4
Female	46	145.7 ± 0.4	5	146.2 ± 1.6	51	145.7 ± 0.4
Both	-		28	145.5 ± 0.6	-	
Flock						
Joined	79	146.1 ± 0.6	32	145.4 ± 1.2	111	145.9 ± 0.5
Unjoined	32	145.3 ± 0.5	10	146.7 ± 1.0	42	145.6 ± 0.4
Class						
1. Weaned	50	146.3 ± 0.8	17	145.4 ± 1.6	67	146.1 ± 0.7
2. Oestrous	30	145.3 ± 0.9	10	146.7 ± 1.8	40	145.6 ± 0.8
3. Lamb Died	10	145.9 ± 1.1	4	146.5 ± 2.1	14	144.2 ± 1.0
4. Acyclic	8	144.6 ± 1.2	6	143.7 ± 1.9	14	144.2 ± 1.0
5. Infertile	13	146.3 ± 0.7	5	146.4 ± 1.4	18	146.3 ± 0.7
Birth Rank	111	145.9 ± 0.5	42	145.7 ± 0.4		

TABLE 4-62 EFFECT OF BREED, FLOCK AND SEX ON GESTATION LENGTH (SINGLE- AND TWIN-BORN LAMBS)

ANOVA

Source of Variation	d.f.	Mean Square	d.f.	Mean Square
	Single-born lambs		Twin-born lambs	
Breed	1	26.937*	1	9.388
Sex	1	2.023	2	2.529
Flock	1	14.773	1	15.699
Breed x Sex	1	0.126	2	9.046
Breed x Flock	1	6.092	1	5.813
Sex x Flock	1	0.237	2	0.002
Breed x Sex x Flock	1	20.970†	2	10.129
Error	103	6.840	30	11.427
Total	110		41	

TABLE 4-63 EFFECT OF BREED, CLASS AND SEX ON GESTATION LENGTH (SINGLE- AND TWIN-BORN LAMBS)

ANOVA

Source of Variation	d.f.	Mean Square	d.f.	Mean Square
	Single-born lambs		Twin-born lambs	
Breed	1	26.285*	1	4.937
Sex	1	1.420	2	5.125
Class	4	8.220	4	10.898
Breed x Sex	1	0.152	2	6.842
Breed x Class	4	3.999	4	3.728
Sex x Class	1	6.308	2	1.499
Breed x Sex x Class	4	7.750	1	35.253
Error	91	6.961	25	11.311
Total	110		41	

TABLE 4-64 EFFECT OF BREED, BIRTH RANK AND FLOCK ON GESTATION LENGTH (ALL LAMBS)

ANOVA

Source of Variation	d.f.	Mean Square
Breed	1	35.073*
Birth Rank	1	7.124
Flock	1	2.097
Breed x Birth Rank	1	0.002
Breed x Flock	1	0.623
Birth Rank x Flock	1	21.237†
Breed x Birth Rank x Flock	1	16.301
Error	145	7.690
Total	152	

TABLE 4-65 EFFECT OF BREED, BIRTH RANK AND CLASS ON GESTATION LENGTH (ALL LAMBS)

ANOVA

Source of Variation	d.f.	Mean Square
Breed	1	30.532*
Birth	1	3.977
Class	4	10.488
Breed x Birth Rank	1	0.949
Breed x Class	4	3.482
Birth Rank x Class	4	5.755
Breed x Birth Rank x Class	4	4.747
Error	133	7.945
Total	152	

and female lambs. Although Joined ewes' lambs were carried for 0.8 days longer than Unjoined ewes' lambs, this difference was not significant. The progeny of Acyclic ewes (144.6 days) had the shortest gestation length while the progeny of Weaned and Infertile ewes (146.3 days) had the longest. However, Class of ewe was not a significant source of variation. Oestrous ewes carried single lambs for one day less than Weaned ewes.

Twin Sets of Lambs

None of the differences between lambs born to Romney (145.0 days) or BLX ewes (146.0 days), Joined (145.4 days) or Unjoined ewes (146.7 days), and born either as a mixed sex set of twins (145.5 days), a male set of twins (145.9 days) or a female set of twins (146.2 days), were significant. The mean gestation length of lambs born to Acyclic ewes was 143.7 days. Other Class of ewe means ranged up to 146.7 days (Oestrous ewes). However, Class of ewe was not a significant source of variation. The breed by sex by class interaction approached significance.

Single-born and Twin Sets of Lambs

The mean gestation length of lambs born to BLX ewes (146.3 days) was significantly ($P < 0.05$) greater than lambs born to Romney ewes (145.4 days). Differences between lambs born to Joined (145.9 days) and Unjoined ewes (145.6 days) were not significant. Single-born (145.9 days) and twin-sets of lambs (145.7 days) were carried for a similar duration. However, the birth rank by flock interaction approached significance. Thus, single-born lambs were carried longer than twin sets of lambs for Joined ewes but shorter for Unjoined ewes. Class effects were not significant.

Birth Day

The effects of various factors on lamb birth day are presented in Table 4-66. The analyses of variance are found in Tables 4-67 and 4-68.

TABLE 4-66 EFFECT OF BREED, FLOCK, CLASS AND BIRTH RANK ON BIRTH DAY

Classification:		No.	Birth Day (August 19 = Day 231) (Mean ± S.E.)
Breed of Ewe			
	Romney	84	231.3 ± 1.4
	BLX	69	230.5 ± 1.1
Flock			
	Joined	111	231.0 ± 1.6
	Unjoined	42	230.8 ± 1.4
Class			
1.	Weaned	67	231.7 ± 2.4
2.	Oestrous	40	230.8 ± 2.5
3.	Lamb Died	14	229.5 ± 3.2
4.	Acyclic	14	228.7 ± 3.2
5.	Infertile	18	231.2 ± 2.1
Birth Rank			
	Single	111	232.2 ± 1.6
	Twin	42	227.5 ± 1.3

TABLE 4-67 EFFECT OF BREED, BIRTH RANK AND FLOCK ON BIRTH DAY (ALL LAMBS)

ANOVA

Source of Variation	d.f.	Mean Square
Breed	1	11.047
Birth Rank	1	669.003**
Flock	1	3.683
Breed x Birth Rank	1	22.049
Breed x Flock	1	11.288
Birth Rank x Flock	1	41.803
Breed x Birth Rank x Flock	1	0.925
Error	145	76.733
Total	152	

TABLE 4-68 EFFECT OF BREED, BIRTH RANK AND CLASS ON BIRTH DAY (ALL LAMBS)

ANOVA

Source of Variation	d.f.	Mean Square
Breed	1	2.627
Birth Rank	1	591.515**
Class	4	21.648
Breed x Birth Rank	1	2.683
Breed x Class	4	51.792
Birth Rank x Class	4	69.865
Breed x Birth Rank x Class	4	11.640
Error	133	79.446
Total	152	

The mean birth day of all lambs was August 19. Breed and Flock had very little effect on mean birth day. Although Class of ewe mean birth days ranged from August 16 (Acyclic) to August 19 (Weaned, Infertile), this was not a significant source of variation.

Single-born lambs were born approximately 5 days later than twin-born lambs. This differences was significant ($P < 0.01$).

IV.6.2 Postnatal Growth

Lamb growth was investigated following the recording of weights at weaning when a total of 161 lambs were weighed. Analyses were carried out on those factors influencing weight at weaning as well as daily gain from birth to weaning.

Weaning Weight

The effect of breed, birth-rearing rank, sex, flock and class on lamb weaning liveweight are presented in Table 4-69. In addition, the analysis of variance included the regression on birth day (Table 4-70, Flock Model; Table 4-71, Class Model).

When testing for homogeneity of within birth-rearing rank regressions only two levels were used. These were in fact within-birth rank since too few lambs were born as twins but reared as singles to include a third level.

The weaning weight difference between BLX (28.45 kg) and Romney progeny (26.74 kg) was highly significant ($P < 0.001$). Lambs born and reared as singles (28.56 kg) were similar in weaning weight to lambs born as twins but reared as singles (29.50 kg). Both of these ranks were significantly heavier than lambs born and reared as twins (25.80 kg). Male-born lambs (28.69 kg) were significantly heavier ($P < 0.001$) than female lambs (26.25 kg). The difference between lambs born to Joined and Unjoined ewes was negligible. Class was a significant source of variation. Lambs born to ewes in Classes 1, 2 and 3 were of similar

TABLE 4-69 EFFECT OF BREED, BIRTH-REARING RANK, SEX, FLOCK AND CLASS ON WEANING WEIGHT AND DAILY GAIN TO WEANING

Classification:		No.	Weaning Weight (kg) (Mean ± S.E.)	Daily Gain (kg/day) (Mean ± S.E.)
Breed of Dam				
	Romney	77	26.64 ± 0.69	0.237 ± 0.007
	BLX	84	28.45 ± 0.48	0.252 ± 0.005
Birth-Rearing Rank				
	Single-Single	91	28.56 ± 1.43a	0.257 ± 0.013a
	Twin-Single	10	29.50 ± 1.35a	0.269 ± 0.012a
	Twin-Twin	60	25.80 ± 1.46b	0.222 ± 0.013b
Sex				
	Male	88	28.69 ± 0.68	0.256 ± 0.007
	Female	73	26.25 ± 0.51	0.231 ± 0.005
Flock				
	Joined	122	27.56 ± 0.82	0.245 ± 0.008
	Unjoined	39	27.67 ± 0.72	0.244 ± 0.007
Class				
1.	Weaned	77	28.25 ± 1.21a[A]	0.251 ± 0.012
2.	Oestrous	38	27.68 ± 1.31a	0.245 ± 0.013
3.	Lamb Died	15	28.33 ± 1.58a	0.248 ± 0.015
4.	Acyclic	15	25.83 ± 1.58b	0.231 ± 0.015
5.	Infertile	16	25.13 ± 1.10b	0.226 ± 0.011

A Means followed by different subscripts are significantly different ($P < 0.05$)

TABLE 4-70 EFFECT OF BREED, SEX, BIRTH-REARING RANK, FLOCK AND BIRTH DAY OF WEANING WEIGHT AND DAILY GAIN TO WEANING

ANOVA

Source of Variation	d.f.	Mean Square (Weaning Weight)	Mean Square (Daily Gain)
Breed	1	278.838***	0.0269***
Birth-Rearing Rank	2	216.026***	0.0320***
Sex	1	209.289***	0.0213***
Flock	1	0.826	0
Breed x Birth-Rearing Rank	2	10.22	0.0003
Breed x Sex	1	2.186	0.0010
Breed x Flock	1	40.682†	0.0030
Birth-Rearing Rank x Sex	2	1.251	0.0006
Birth-Rearing Rank x Flock	2	8.709	0.0015
Sex x Flock	1	15.069	0.0010
Regression on Birth Day (Within-birth-rank)	2	264.972***	-
Pooled within-classes regression	1	438.029***	-
Difference	1	81.914**	-
Error		12.250 (144 df)	0.0013 (114 df)
Total	160		

TABLE 4-71 EFFECT OF BREED, SEX, BIRTH-REARING RANK, CLASS AND BIRTH DAY ON WEANING WEIGHT AND DAILY GAIN TO WEANING

ANOVA

Source of Variation	d.f.	Mean Square (Weaning Weight)	Mean Square (Daily Gain)
Breed	1	230.454***	0.0222***
Birth-Rearing Rank	2	192.448***	0.0302***
Sex	1	203.258***	0.0208***
Class	4	27.484*	0.00127
Breed x Birth-Rearing Rank	2	8.301	0.00069
Breed x Sex	1	3.732	0.00108
Breed x Class	4	16.610	0.00185
Birth-Rearing Rank x Sex	2	0.078	0.00029
Birth-Rearing Rank x Class	8	16.411	0.001798
Sex x Class	4	7.376	0.00055
Regression on Birth Day (Within-birth-rank)	2	268.858***	-
Pooled within-classes regression	1	397.200***	-
Difference	1	140.515***	-
Error		11.562 (129 df)	0.00124 (131 df)
Total	160		

weight at weaning (~28 kg) while lambs born to ewes in Classes 4 and 5 were of a similar (~25.5 kg) but significantly lighter ($P < 0.05$) weight. (N.B. Duncan's New Multiple Range Test was applied at the 5% level of significance for Class differences).

The pooled within-classes regressions on birth day ($b = -0.231 \pm 0.039$ and $b = -0.228 \pm 0.041$ kg/day for Flock and Class Models respectively) were highly significant ($P < 0.001$). Furthermore, the relationship between weaning weight and birth day differed significantly for single-born and twin-born lambs. The respective values of b from the Flock Model were $b = -0.282$ and $b = -0.002$ ($P < 0.01$) and from the Class Model, $b = -0.289$ and $b = -0.084$ kg/day ($P < 0.001$). The regression coefficients for twin-born lambs were not significantly different from zero ($t < 1.6$, $P > 0.1$).

Daily Gain to Weaning

The mean daily gain to weaning for various factors are shown in Table 4-69, and the analyses of variance in Tables 4-70 and 4-71. The mean gain was 0.245 kg per day.

Lambs born to BLX ewes (0.252 kg/day) grew significantly faster ($P < 0.001$) from birth to weaning than lambs born to Romney ewes (0.237 kg/day). Lambs born as twins but reared as singles (0.269 kg/day) grew faster (N.S.) than lambs born and reared as singles (0.257 kg/day). Lambs from both of these ranks grew significantly faster ($P < 0.01$) than twin-born and -reared lambs (0.222 kg/day). Male-born lambs (0.256 kg/day) were superior ($P < 0.001$) to female lambs (0.231 kg/day) in daily gain. Lambs born to ewes in Flocks 1 and 2 grew at a similar rate. Weaned ewes' lambs (0.251 kg/day) gained in liveweight at the fastest rate while Infertile ewes' lambs grew the slowest (0.226 kg/day). However, none of the Class differences were significant.

IV.6.3 Survival to Weaning

The effect of breed of dam, sex, birth rank of lamb, flock and class on survival to weaning are shown in Table 4-72.

A preliminary fitting of main effect Flock and Class Models indicated that the logit model was inappropriate (Flock Model: error χ^2 = 163.816, 184 d.f.; Class Model: error χ^2 = 148.509, 172 d.f.).

The survival of BLX ewes' lambs (85.7%) was slightly higher than the survival of Romney ewes' lambs (79.4%). However, when male and female lambs were compared, the superior survival of female lambs was clear (88.0% versus 78.6%). Surprisingly, the small birth rank difference favoured twin-born lambs (83.3% versus 82.0%). Lambs born to ewes in the Joined Flock (85.3%) were more likely to survive than lambs born to ewes in the Unjoined Flock (75.0%).

Lambs born to ewes that had previously weaned lambs (Weaned) were more likely to survive (91.7%) than lambs born to ewes that had previously lambed but failed to rear lambs (Lamb Died, 83.3%). Lamb survival was lower in ewes that had not previously lambed (Oestrous, 76.0%; Acyclic, 75.0% and Infertile, 69.6%).

TABLE 4-72 EFFECT OF BREED, BIRTH RANK, SEX, FLOCK AND CLASS ON LAMB SURVIVAL TO WEANING

Classification:		No.	Survival to Weaning (%)
Breed of Dam			
	Romney	97	79.4
	BLX	98	85.7
Sex of Lamb			
	Male	111	78.6
	Female	84	88.0
Birth Rank			
	Single	111	82.0
	Twin	84	83.3
Flock			
	Joined	143	85.3
	Unjoined	52	75.0
Class			
1.	Weaned	84	91.7
2.	Oestrous	50	76.0
3.	Lamb Died	18	83.3
4.	Acyclic	20	75.0
5.	Infertile	23	69.6

RESULTS (EXPERIMENT II)

CHAPTER V

RESULTS (EXPERIMENT II)

V.1 Liveweight of Ewe Lambs

There was very little change in the liveweight of the ewe lambs over April 14 to June 30. The 48 lambs receiving two fertilized ova weighed 36.0(±0.5)kg, 36.5(±0.6)kg and 36.3(±0.5)kg on April 14 (pre-joining liveweight) at laparotomy (laparotomy liveweight) and on June 20 (post-laporatomy liveweight) respectively. The mean weights of all remaining lambs were similar to these at the respective weighings (the liveweights of lambs not subject to laparotomy were recorded on May 31).

V.2 Ewe Lamb Performance

V.2.1 Oestrus; Insemination; Ovulation; Ovum Recovery, Cleavage and Transfer

Over 80% of lambs and 90% of the ewes were marked over the April 29 - May 31 period (Table 5-1). Only two lambs failed to be inseminated at first service. Both were marked within the first two days of joining. One of these returned to oestrus and was inseminated.

Three lambs were observed to be anovular at laparotomy. One lamb was recorded with one large unruptured follicle. The other two lambs each had a pair of large unruptured follicles. All ewes were found to be ovular.

Only 6% of the ovular ewe lambs shed two ova compared to almost 33% of the ewes. No triple ovulating animals were recorded.

Approximately 80% of ova were recovered. There was little difference between lambs and ewes. While two of the ewe lamb ova each had a ruptured zona pellucida, none of the ewe ova were damaged in this manner. Furthermore, six ewe lamb and two ewe ova had

TABLE 5-1 OESTRUS; INSEMINATION; OVULATION; OVUM RECOVERY, CLEAVAGE AND TRANSFER

	Ewe Lamb	Ewe	Both
No. Joined	109	108	217
No. Marked (%)	87 (80.7)	100 (92.6)	187 (86.6)
No. Inseminated (%)	85 (97.7)	-	-
No. Laparotomised	86	70	156
No. Anovular (%)	3 (3.5)	0	3 (1.9)
No. Corpora Lutea (%)	88 (106.0)	93 (132.9)	181 (118.3)
No. Ova Recovered (%)	72 (81.8)	74 (79.6)	146 (80.7)
No. with intact Zona Pellucida (%)	70 (97.2)	74 (100)	144 (98.6)
No. Cleaved (%)	64 (91.4)	67 (90.5)	131 (91.0)
No Transferred (%)	48 (75.0)	48 (71.6)	96 (73.3)
Recovery to Transfer Interval (mins) A	18.3 ± 2.7	24.4 ± 2.8	21.4 (±2.0)

A Mean ± S.E.

indented zonae pellucidae.

The cleavage rate (more than 1 cell) was high for all ova ($\sim$ 90%). A little less than three quarters of cleaved ova were matched and transferred. The ewe lamb ova transferred were in vitro for a mean period of 18.3 minutes. Ewe ova were an additional six minutes between recovery and transfer.

In addition to the 48 single ovulating lambs receiving paired ova, three multiple ovulating lambs received paired ova and one a solitary lamb ovum; nine single ovulating lambs received a lamb ovum each, four a ewe ovum each and six with unrecovered ova received one ewe ovum each. The remaining twelve laparotomised lambs yielded no ova and none were transferred into these.

V.2.2 Conception and Lambs Born

The effect of breed of (ewe lamb) mate on conception and lambs born per ewe for the 48 lambs receiving paired ova are shown in Table 5-2.

Approximately 60% of the lambs conceived. A preliminary model fitting showed conception to be independent of breed, pre-joining, laparotomy and post-laparotomy liveweights as well as pre-joining to laparotomy daily gain (pre-laparotomy daily gain) and laparotomy to June 20 daily gain (post-laparotomy daily gain).

The incidence of twinning ewe lambs per ewe lambing was 23.5% and 33.3% for ewe lambs mated by Romney and Suffolk sires respectively (χ^2_c = 0.02, N.S.).

The incidence of lambs born per ewe (receiving paired ova) were 84.0% and 69.6% for ewe lambs mated by Romney and Suffolk sires respectively (χ^2_c = 0.09, N.S.).

TABLE 5-2 CONCEPTION AND LAMBS BORN FOLLOWING THE TRANSFER OF EWE LAMB AND EWE OVA INTO THE UTERI OF EWE LAMBS

	Breed of Mate (Ewe Lamb)		
	Romney	Suffolk	Both Breeds
No. ewes	25	23	48
No. Lambing (%)	17 (68.0)	12 (52.2)	29 (60.4)
- Singles (%)	13 (76.5)	8 (66.7)	21 (72.4)
- Twins (%)	4 (23.5)	4 (33.3)	8 (27.6)
% Lambs Born Per Ewe	84.0	69.6	77.1

V.2.3 Ovum Survival

The effect of several factors on the survival of ova are presented in Table 5-3. Overall, 38.5% of ova survived. There was little difference between Romney and Suffolk genotypes in the survivability of ova. However, the survival rate of ova from mature donors was significantly greater ($P < 0.01$) than ova from ewe lamb donors. Thus, more than twice as many ewe ova (52.1%) than lamb ova (25.0%) survived.

Preliminary covariance analyses indicated the independence of ovum survival and laparotomy liveweight, post-laparotomy liveweight, post-laparotomy gain, and the interval between ovum recovery and transfer. However, the regression on pre-joining liveweight approached significance. Thus, increases in prejoining liveweight were associated with a reduction in ovum survival. The odds ratio multiplicative factor was 0.899 per kg increase in prejoining liveweight.

V.3 Ewe Lamb Progeny Performance

V.3.1 Prenatal Growth

Day of Birth

The effect of breed, birth rank and sex on birth day are shown in Tables 5-4 and 5.5. The mean day of birth was day 277 (October 4).

Breed of sire and sex of lamb differences were very small. However, twin lambs were born 2.5 days later than single lambs (N.S.).

Gestation Length

Tables 5-4 and 5-5 contain the effect of breed, birth rank and sex on gestation length. The mean gestation length was 146.6 days.

Suffolk-sired and single-born lambs remained in utero for almost 1 day longer than Romney-sired and twin-born lambs respectively. Neither of the differences were significant. Male and female lambs had similar gestation lengths.

TABLE 5-3 SURVIVAL OF FERTILIZED OVA FROM ADULT EWES AND EWE LAMBS WHEN TRANSFERRED INTO THE UTERI OF EWE LAMBS

	Age of Donor					
	Ewe Lamb		Ewe		Both Ages	
	No.	% Survival	No.	% Survival	No.	% Survival
Breed of Mate						
Suffolk	23	21.7	25	56.0	48	39.6
Romney	25	28.0	23	47.8	48	37.5
Both Breeds	48	25.0	48	52.1		

ANOVA

Source of Variation	d.f.	Deviance
Breed	1	0.010
Age	1	7.521**
Breed x Age	1	0.562
Regression on April 14 Liveweight		
(Pooled within-classes)	1	2.896†
Error	91	116.974
Total	95	

TABLE 5-4 EFFECT OF BREED, BIRTH RANK AND SEX ON DAY OF BIRTH AND GESTATION LENGTH (ALL LAMBS)

Classification:	No.	Day of Birth (January 1 = Day 1) (Mean ± S.E.)	Gestation Length (Days) (Mean ± S.E.)
Breed of Sire			
Romney	34	277.7 ± 1.9	146.3 ± 0.7
Suffolk	24	277.7 ± 1.5	147.1 ± 0.5
Birth Rank			
Single	36	277.1 ± 2.1	146.8 ± 0.8
Twin	22	279.6 ± 1.9	146.0 ± 0.7
Sex			
Male	30	277.8 ± 1.9	146.5 ± 0.7
Female	28	277.5 ± 1.4	146.7 ± 0.5

TABLE 5-5 EFFECT OF BREED, BIRTH RANK AND SEX ON DAY OF BIRTH AND GESTATION LENGTH (ALL LAMBS)

ANOVA

Source of Variation	d.f.	Mean Square	
		Day of Birth	Gestation Length
Breed	1	8.852	0.540
Birth Rank	1	7.223	53.405
Sex	1	0.667	0.652
Breed x Sex	1	6.866	20.349
Breed x Birth Rank	1	1.363	57.085
Birth Rank x Sex	1	10.185	9.383
Breed x Birth Rank x Sex	1	1.330	44.482
Error	50	4.808	37.612
Total	57		

Birth Weight

The effect of breed, birth rank and sex on lamb birth weight are contained in Tables 5-6 and 5-7. The mean birth weight was 3.06 kg.

Breed of sire and sex of lamb effects were small. However, twin lambs were almost 1 kg lighter than single lambs ($P < 0.001$).

V.3.2 Survival

Breed, birth rank and sex effects on lamb survival to October 30 are shown in Tables 5-6 and 5-8. Mean lamb survival was 74.1%.

Cross-bred lambs (79.2%) had better survival rates than straight-bred lambs (70.6%) while female lambs (82.1%) were more likely to survive than male lambs (66.7%). However, neither difference was significant. The markedly lower survival rate of twins (54.5%) compared to single-born lambs (86.1%) was significant ($P < 0.01$).

The pooled within-classes regression on birth weight and birth weight squared approached significance.

TABLE 5-6 EFFECT OF BREED, BIRTH RANK AND SEX ON BIRTH WEIGHT AND SURVIVAL (ALL LAMBS)

Classification:	No.	Birth Weight (kg) (Mean ± S.E.)	Survival (%)
Breed of Sire			
Romney	34	3.09 ± 0.25	70.6
Suffolk	24	3.00 ± 0.19	79.2
Birth Rank			
Single	36	3.42 ± 0.22	86.1
Twin	22	2.46 ± 0.17	54.5
Sex			
Male	30	3.08 ± 0.25	66.7
Female	28	3.03 ± 0.18	82.1

TABLE 5-7 EFFECT OF BREED, BIRTH RANK AND SEX ON BIRTH WEIGHT (ALL LAMBS)

ANOVA

Source of Variation	d.f.	Mean Square
Breed	1	0.134
Birth Rank	1	13.057 ***
Sex	1	0.507
Breed x Birth Rank	1	0.046
Breed x Sex	1	0.017
Birth Rank x Sex	1	0.170
Breed x Birth Rank x Sex	1	0.011
Error	50	0.704
Total	57	

TABLE 5-8 EFFECT OF BREED, BIRTH RANK, SEX AND BIRTH WEIGHT ON LAMB SURVIVAL (ALL LAMBS)

ANOVA

Source of Variation	d.f.	Deviance
Breed	1	0.807
Birth Rank	1	7.087**
Sex	1	0.639
Breed x Birth Rank	1	0.674
Breed x Sex	1	0.178
Birth Rank x Sex	1	1.073
Breed x Birth Rank x Sex	1	0.334
Regression on Birth Weight (BT)+ Birth Weight^2 (BT^2) (Pooled within-classes)	2	5.138†
Error	48	47.394
Total	57	

DISCUSSION

CHAPTER VI

DISCUSSION

VI.1 Liveweight of Ewes

The ewe lambs were considered adequately grown at joining in both years. The Romney lambs were close to the autumn target liveweight (35 kg) and BLX lambs a little heavier than is suggested by research results (Anon, 1979). The liveweight advantage of single over twin-born ewes was less than those commonly reported at weaning (Ch'ang and Rae, 1961; Clarke, 1967; Hight and Jury, 1971) but similar to those reported for autumn liveweight (Ch'ang and Rae, 1970; Baker et al., 1979). These birth and/or rearing rank effects are assumed to be largely a function of the extent to which prenatal uterine environment and postnatal milk supply are shared by twin but not single lambs.

Pregnant lambs were heavier than Infertile lambs at joining. The effect was larger in BLX (2.3kg) than Romney lambs (1.0kg). A similar effect seems probable in Corriedale ewe lambs (Ponzoni et al., 1979). Baker et al., (1978) reported a weaning weight difference between these two classes for Dala but not Steigar ewes. It seems that the joining liveweight difference between Pregnant and Infertile ewes is generally small (< 2 kg).

Oestrous Romney lambs were almost 7 kg heavier than Acyclic Romney lambs at joining. In fact, the difference between these two classes remained relatively static throughout the experiment. In general, this applied to BLX animals although the difference was usually small (< 1 kg). Differences in autumn liveweight of 2 - 3 kg have been reported for Romney lambs elsewhere in New Zealand (Ch'ang and Raeside, 1957; Lewis, 1959; Hight et al., 1973; Allison et al., 1975;

Allison and Kelly, 1978). Keane (1974c) has reported differences of 4 kg in Suffolk cross-bred lambs. A similar difference in autumn liveweight has been reported for BLX lambs (Hight, Lang and Jury, 1973) as well as Coopworth and Perendale lambs (Allison and Kelly, 1978). In some instances, liveweight differences are small, particularly as animals get older (Hulet et al., 1969; Baker et al., 1978; Ponzoni et al., 1979). Cleverdon (1980) recently presented evidence indicating the presence of genotype-environment interactions in relation to liveweight differences between oestrous and non-oestrous ewe lambs.

The greater gains achieved during the first autumn in favour of twin- over single-born lambs indicates post-weaning compensatory growth. As in other studies (Ch'ang and Rae, 1970; Hight and Jury, 1971), this phenomenon decreases in magnitude with increasing age.

The significantly higher gain by Joined ewes over the ewe lamb mating season was most likely due to differences in pasture dry matter offered. Although it was intended to graze both flocks as alike as possible over the mating season, it became necessary to set stock Unjoined ewes until June 3 as other paddocks of suitable size were not available. Over the same period, Joined ewes were shifted between several paddocks every 5 - 8 days.

This problem can be overcome in future experimental designs by grazing all animals together and replacing the entire rams with teaser rams for varying intervals at strategic times throughout mating.

The significant breed difference in gain over the first winter in Pregnant ewes but none of the other classes can most likely be explained by the greater advancement of pregnancy for BLX compared to Romney ewes. BLX ewes lambed six days earlier than Romney ewes. Although some of the difference could be genetic in origin, it is impossible to partition this out in the present experiment.

There is a lack of published information on the extent to which bodyweight should be increased in late pregnancy so as to optimize lamb birth weights, minimize dystocia and maximize lamb survival for ewes lambing at one year. This information is urgently required if a high level of lamb production from immature ewes is to be achieved.

The level of nutrition provided for the pregnant lambs in the current study resulted in Pregnant ewes weighing 8.4 kg and 3.9 kg heavier than Oestrous ewes for BLX and Romney ewes, respectively, some 3 weeks prior to the mean lambing date. In view of the poor lamb survival ensuing even though mean birth weights were 4 kg and only 4 of the 96 pregnant ewes needed assistance, it may have proved opportune to improve the level of nutrition so as to raise mean birth weights and hopefully survival without increasing the assistance rate. Clearly, more information on these aspects is required.

Briggs (1936) reported a 5 - 6 kg difference between pregnant and non-pregnant lambs prior to lambing. Furthermore, McCall (1980) found that twin-bearing ewe lambs were heavier prelambing than single-bearing ewe lambs.

Quirke et al., (1978) have shown that prepartum liveweights can be improved by 6 kg as a result of increased energy intake during the last 100 days of pregnancy. This confirmed earlier British investigations (Robinson et al., 1971). Losses in maternal liveweight of 8 - 10 kg at parturition in ewe lambs have been reported in two overseas studies (Robinson et al., 1971; Quirke et al., 1978).

Post-partum liveweights continued to increase during the second spring inspite of lactation. However, non-parous ewes gained significantly more weight than parous and suckling ewes in particular. This trend continued through the second summer. It was in late October and early November that lactation in Romney and BLX ewes respectively resulted in Weaned and Oestrous ewes of similar mean liveweight.

This would suggest that suckling periods in excess of three weeks lead to a reduction in the liveweight of these ewes relative to ewes showing oestrus during the ewe lamb breeding season.

Consideration could be given to weaning lambs as early as 3 - 5 weeks of age since lambs are known to be physiologically capable of existing on solid feed alone at about 3 weeks of age (Wardrop and Coombe, 1961; Walker and Walker, 1961). There are several management advantages accruing to weaning at younger ages: ewes will suffer less with respect to liveweight gain and wool production; and the lambs do not have to compete with their dams for feed (early weaning and lamb growth will be discussed later).

By the end of November, 1977 lactating ewes were 4 - 5 kg lighter than Oestrous ewes. This difference indicates that lactating ewes lost approximately 1 kg per week over this month, relative to Oestrous ewes, as a consequence of suckling lambs.

The 1 kg difference between Early and Late Weaned ewes on November 30 and the suggestion of an interaction with breed is most likely a chance outcome of the randomization process. In view of this, it is more meaningful to look at the short term effects of the weaning treatments in terms of liveweight changes. Thus, early weaning resulted in these ewes gaining approximately 2 kg more than unweaned ewes over the 21 day interval between weanings. However, Early Weaned ewes gained significantly less than Oestrous ewes over this interval even though they were grazed together. This post-weaning check could perhaps be explained by a degree of fretful behaviour by the weaned ewes, particularly during the first week after weaning. Observations were not carried out to confirm this, although all ewes rearing lambs in this study displayed excellent maternal behaviour during rearing and it seems reasonable to expect weaning to elicite behavioural changes resulting in reduced feed intake.

Although the difference was not significant, Late Weaned ewes grew slower than Oestrous ewes over their first 21 days post-weaning. These ewes thus appeared to suffer a post-weaning check, probably for the same reason. It is difficult to explain why Early Weaned ewes did not grow faster than Late Weaned ewes over this 21 day period. However, by this stage of the summer the district, along with much of New Zealand, was entering a serious drought (Anon, 1978). In spite of this, Early Weaned ewes gained more than Late Weaned ewes over the summer, although nearly all of the advantage occurred during early December.

The consequence of the drought on pasture quality and quantity can be seen by the loss of ewe liveweight over their second autumn. Thus, ewes weighed as much in late autumn (May) as they did in late spring (November). The 1 - 2 kg loss of liveweight over the early two-year-old ewe mating season is reported to be detrimental to lamb production through its affect on ovulation rate (Rattray et al., 1980). These workers maintain that loss of weight around the mating season in low liveweight ewes (45 - 50 kg) leads to relatively large reductions in multiple ovulation rate (2 - 3% per kg loss) and lambing performance.

The flock difference in two-year-old ewe joining liveweight was close to 3 kg. Furthermore, while the effects of the weaning treatments were small in Romney ewes, quite large differences ($\sim$ 4 kg) persisted in BLX ewes. However, part of these differences could have been carried over from differences existing on November 30. When gains from November 30 to March 15 are considered, the advantage to Early Weaned ewes was 1.3 kg and 2.3 kg for Romney and BLX ewes respectively. Furthermore, since Oestrous ewes from both breeds gained similar amounts of liveweight to the Early Weaned ewes in the same breed, over this period, there was no evidence of compensatory growth.

This result was expected since ewes were not well fed over the post-weaning period (see review by Wilson and Osbourne, 1960). Other evidence suggests that the closer an animal is to mature size when underfed, the greater the amount of compensatory growth expected (Morgan, 1972). The evidence would therefore suggest that liveweight differences at weaning between suckled and control ewes will almost totally persist through to two-year-old joining if preferential feeding is not practiced and both groups are not subsequently well fed. This can occur during dry summers. However, if both groups are well fed after weaning, then high levels (> 50%) of compensatory growth are likely to be achieved. If suckled ewes are preferentially fed more of the liveweight deficit would be made up than would otherwise be the case.

The amount of liveweight that has to be compensated for, as mentioned earlier, is largely influenced by the extent to which weaning is delayed beyond early November.

Although there was some compensatory growth by suckled ewes over their second winter, most of this was lost during the following spring, particularly in the case of Early Weaned ewes. When the total gain is considered, the effects of weaning treatment were small and not significant. The lower total gains for each of the weaned groups compared to Oestrous ewes are partly directly attributable to the higher weaning performance of the previously parous ewes. Although the differences were 4 - 5 kg at the two-year-old weaning, they would not be expected to be carried over into the next year (Briggs, 1936; Mair, 1963; Williams, 1954; Tyrell, 1976; Southam et al., 1971; Ponzoni et al., 1979).

The current findings support the conclusion that suckling in ewe lambs can check early growth and development but only temporarily (Dyrmundsson, 1973). Furthermore, weaning earlier can lessen the extent to which liveweight is depressed.

VI.2 Ewe Lamb Performance

VI.2.1 Incidence of Oestrus

The level of oestrous activity in Romney ewe lambs in both experiments is high in comparison with other New Zealand reports (Ch'ang and Raeside, 1959, 72%; Hight et al., 1973, 55%; Allison et al., 1975, ∿ 43%; Allison and Kelly, 1978, 47%; Meyer and French, 1979, 25%). Some of the variation can be accounted for by differences in the timing and duration of the joining season in relation to the breeding season. However, a more important factor would be the autumn liveweight of the ewe lambs. Although insufficient data was available in the present study to quantify the relationship between autumn liveweight and oestrous activity, it is widely recognized that the relationship is positive (Dyrmundsson, 1973). Thus, Moore et al., (1978) clearly demonstrate a large difference in the incidence of oestrus (50%) for ewe lambs varying in mean autumn liveweight (a result of differential post-weaning nutrition) by approximately 10 kg. Cleverdon (1980) reports a similar trend in Romney ewe lambs following differential feeding.

Although BLX lambs are reported to be more precocious than Romney ewe lambs (Hight et al., 1973), they are also heavier. These workers show a similar incidence of oestrus in the two genotypes when considered at the same autumn liveweight and furthermore, only small genotype differences in oestrous response resulting from increases in autumn liveweight. However, since the Romney lambs in the present study that showed oestrus were some 5 - 6 kg heavier at joining than anoestrous lambs and the difference was negligible in BLX lambs, genotypic differences in oestrous incidence-liveweight relationships are possible. Allison et al., (1975) also show breed differences in liveweight between marked and unmarked lambs even when breed differences in joining liveweight are small.

The mechanism by which liveweight influences oestrus in ewe lambs is not clearly understood. Foster and Ryan (1979) present two hypotheses to explain the complete mechanism for the transition of the lamb into adulthood. Central to the hypothesis for the onset of the pubertal process is the postulate of a marked decrease in the response of the negative feedback action of oestradiol on tonic LH secretion. Furthermore, parallels are drawn between the onset of the breeding season in adult ewes, where photoperiod appears to be the primary stimulus, and puberty, where the nature of the stimulus remains to be determined. A recent report by Foster (1980) indicates that in lambs born out of their natural birth season, environmental factors delay first ovulation by delaying the reduction in negative feedback responsiveness to oestradiol until the developing female enters an appropriate season for reproduction. This could account for the lower incidence of oestrus often observed in late-born lambs (Dyrmundsson, 1973). However, Keane (1975c) reports that much of the effect of birth date is accounted for by liveweight differences.

VI.2.2 Inter-oestrus Interval

Unlike the situation in older ewes, the interval between successive oestruses showed a high degree of variability: the range was from 5 to 34 days. Inspite of this, the mean interval of between 17 and 18 days agrees with the 17.24 days recorded in Romney lambs (Ch'ang and Raeside, 1957). However, these authors reported a range from 14 - 23 days.

It has been known for some time that ewe lambs exhibit less regular intervals between oestruses than mature ewes (Hafez, 1952; Mounib et al., 1956) although the mean duration is close to that recorded in adults (Goot, 1949; Dyrmundsson, 1978). The latter author reported that 8% of the oestrous cycle lengths of ewe lambs and ewes were less than 14 days whereas 31% and 16% respectively, were longer than 19 days in the Icelandic breed. The finding that lambs experiencing more oestruses tend to have more regular cycles (Sefidbakht et al., 1966; Hulet et al., 1969; Foote et al., 1970) is somewhat expected given the seasonality of oestrous activity in ewe lambs.

The incidence of extended oestrous cycles (> 19 days), sometimes called multiple cycles, is variable (Bichard et al., 1974, 14%; Dyrmundsson and Lees, 1972a, 9%; Quirke, 1978b, 12% - 36%; Cleverdon, 1980, 7%) and can occur in 15 - 25% of ewe lambs (Dyrmundsson and Lees, 1972a; Cleverdon, 1980).

Although there was no obvious trend in the present study, Hafez (1951, 1952) and Keane (1975a) note that multiple cycles are more frequent toward the end of the breeding season. Cleverdon (1980) reports small breed and plane of nutrition effects on the frequency of multiple cycles. However, she found significant breed effects on the proportion of ewe lambs experiencing multiple cycles (15% - 35%) but only small plane of nutrition effects.

The cause of multiple cycles remains to be ascertained. However, it appears that ovulation does occur at the expected time (Cleverdon, 1980). Although the hypothesis that oestrus at this time is of such short duration and/or low intensity that rams are unable to detect these lambs, can be advanced to explain those intervals greater than 30 days, it is difficult to explain those intervals of 20 - 30 days duration.

Furthermore, the cause of intervals of less than 14 days also remains unanswered.

VI.2.3 Insemination Failure

During the early stages of ewe lamb joining in Experiment I, attempts at swabbing for the presence or absence of anterior vaginal sperm proved impractical (primarily as a result of staff unavailability). However, the relatively high first service conception rate in these lambs, BLX in particular, suggests that insemination failure is not a large source of reproductive wastage.

The two lambs that failed to be inseminated in Experiment II were of similar liveweight (∿ 33 kg) and were marked within two days of joining. The intensity of the crayon marks indicated that 'rape' was an unlikely explanation. Allison <u>et al</u>., (1975) show that 70 - 75% of lambs marked by two or fewer rams may fail to be inseminated. In some unpublished work Allison suggests that ewe lambs marked by rams but not inseminated and anovular may be false recordings due to 'rape' markings from enthusiastic rams at the beginning of the joining period, especially when few oestrous lambs are present. Since the two non-inseminated lambs in Experiment II were not laparotomized, the possibility that the oestrus was a false recording cannot be excluded.

One of these two lambs returned to service and was inseminated. The other presumably returned to anoestrum as it failed to return to service and did not lamb.

The low insemination failure rate in Experiment II is most likely a reflection of: 1. plot size (0.42 ha); 2. ram ages (mixed age); 3. rotating rams (every 3 - 7 days) and, 4. the high ram;ewe lamb ratio (3 - 4:100). All of these factors would aid successful insemination (Edey <u>et al</u>., 1978).

However, it should be noted that under apparently ideal mating management, insemination failure can still occur. Thus, Chu (1977) reports 77.4% of 62 lambs inseminated following paddock and then pen mating compared to 70% of 20 lambs mated in the paddock only.

VI.2.4 Number of Oestruses

The mean number of oestruses of 3 - 3.5 are more than previously recorded for Romney lambs in New Zealand (Ch'ang and Raeside, 1957, 2.7; Hight et al., 1973, 1.4; Baker et al., 1974, 1.7). Cleverdon (1980) recorded values of 2.9 and 3.5 for Romney lambs on low and high planes of nutrition respectively. Although Border Leicester cross-breeding can increase the number of oestruses (Hight et al., 1973; Cleverdon, 1980) there was no such effect in the present study. This might simply be a consequence of commencing the recording of oestrous activity too far into the breeding season.

Number of oestruses has practical implications for several reasons. Firstly, it may form the basis of an early indirect means of selecting for fecundity (Ch'ang and Rae, 1970; 1972). Secondly, it allows the use of teaser rams to detect returns to service in flocks of lambs where entire joining has been practiced (more on this in subsequent discussions). Thirdly, increasing oestrous experience may enhance ewe lamb fertility (Edey et al., 1978, however, indicate that this is unlikely) or even two-year-old fertility. There is little information on this latter point although discussions with farmers indicate that some join unharnessed teaser rams with ewe lambs in the belief that aspects of mating behaviour 'learnt' at this stage will be carried over to the two-year-old mating season and result in improved conception. A fourth point would be the laparoscopic recording of ovulation rate at consecutive oestruses and its use as a criterion of indirect selection for fecundity (Hull and Manning, 1980).

Although, the design did not allow the recording of dates of first oestrus, it is clear that oestrous activity was at a peak during

May. This is in agreement with other New Zealand work (Ch'ang and Raeside, 1957; Lewis, 1959; Hight et al., 1973).

The number of ewe lamb oestruses is increased by the inclusion of high fecundity genotypes into the Romney (Meyer and French, 1979; Cleverdon, 1980); Border Leicester crossbreeding (Hight et al., 1973) and high levels of post-weaning nutrition (Moore et al., 1978; Cleverdon, 1980).

VI.2.5 Ovarian Activity

Of the 128 lambs examined for ovarian activity, only 4 (3.1%) were anovular. In each case at least one large (> 8 mm) unruptured follicle was in evidence. Edey et al., (1977) reported that 6.6% of 61 Perendale lambs and 33.3% of 39 Merino lambs were anovular at first oestrus. Furthermore, some lambs were anovular at several oestruses and prior ovulation accompanied by oestrus did not preclude further anovular oestruses. Allison (unpublished) found 6.9% of 203 marked lambs to be anovular and contain large unruptured follicles. However, two studies involving large numbers of ewe lamb laparotomies (Hight et al., 1973; 511 observations) and repeat laparoscopies (Cleverdon, 1980; 3032 observations) did not report any anovular oestruses. Hamra and Bryant (1979) recorded that 3 out of 218 lambs were anovular and had large unruptured follicles.

Edey et al., (1978) concluded that failure of ovulation was followed by luteinization of one or more large (> 8 mm diameter) follicles.

There is no satisfactory explanation for failure of ovulation in some oestrous lambs. However, Ryan and Foster (1978) discovered a cycle of less than 8 days that precedes first oestrus/ovulation by about three weeks. They suggest that the mechanism governing the LH surge at this time is triggered by early increases in circulating oestradiol from the developing preovulatory follicle produced as a result of tonic LH secretion (Foster et al., 1975a, b) and furthermore, follicular luteinization may result. Perhaps the oestrogen threshold for the display of oestrus is lower than for ovulation in some prepuberal lambs. Both of these findings could, in part, explain the formation of large unruptured follicles at oestrus as well as the anovular oestrus state in Romney lambs grazing oestrogenic red clovers (Ch'ang, 1958).

The incidence of multiple ovulation in Romney ewe lambs in Experiment I (4.6%) and II (6.0%) is about half those reported by Hight et al., (1973) and Meyer and French (1979) and substantially less than in a recent report (Cleverdon, 1980). It is difficult to account for this variation between studies in terms of autumn liveweight in view of the general findings of Dyrmundsson (1973). Genetic differences between flocks may explain some of the variation since Cleverdon (1980) implicates between sire variation in breeding value for this trait.

The finding that single-born lambs experience more multiple ovulations than twin-born lambs is consistent with the finding in Romney lambs reported by Hight et al., (1973). However, these authors report a slightly higher multiple ovulation incidence in twin- over single-born BLX lambs. Cleverdon (1980) reports significant breed by birth rank interactions: ovulation rates are higher in multiple-born Booroola x Coopworth and (Booroola x Romney) x Romney lambs but the opposite was the trend in (Booroola x Coopworth) x Coopworth lambs.

In view of the low incidence of multiple ovulation in the current study, it is not surprising that this variable was independent of autumn liveweight. However, as shown in other studies (Keane, 1974c;

1975c; Meyer and French, 1979; Bryant and Hamra, 1979) multiple ovulating lambs are heavier than single ovulators (Experiment I: 1.9 kg; Experiment II: 1.4 kg). However, Cleverdon (1980) shows this to be dependent on breed and nutritional level. For example, multiple ovulators were heavier in the Romney lambs on a high plane but there was little difference between low plane Romneys.

Cleverdon (1980) showed a significant effect of nutritional plane on ewe lamb first oestrous (+ 0.29 ova per ewe lamb) and all oestruses (+0.16 ova per ewe lamb) ovulation rate. This is at variance with reports by Lamming (1963), Keane (1974c; 1975c) and also Williams (1954) who indicate no flushing response in ewe lambs. Clearly, there are factors other than liveweight which influence the incidence of multiple ovulation in immature ewes.

If the incidence of multiple ovulation is relatively insensitive to liveweight in the ewe lamb then attempts to improve oestrous activity in ewe lambs over the mating season are unlikely to result in an increase in twinning. It is generally advisable for ewe lambs to rear one lamb, particularly if the lambs are to be weaned early and both lamb and dam are not then preferentially fed.

VI.2.6 Conception

The conception rates to first service for Romney ewe lambs in both Experiment I (67.2%) and II (60.4%) are higher than is apparent for Romney lambs in another New Zealand study (Lewis, 1959, 52.5%). Furthermore, the 82.5% for BLX lambs is markedly superior to that apparent for lambs of similar genotype, also in New Zealand studies (Allison et al., 1975: ~ 57%). A third New Zealand study involving well grown Perendale lambs (Edey et al., 1978) noted a very low first service conception rate (37.7%). Numerous overseas studies confirm these low first service conception rates: Gordon, 1967b, 57.1%, N = 28;

Keane, 1974a, 56.5%, N = 384; Keane, 1974c, 45.6%, N = 252; Quirke, 1978b, 27.7%, N = 505; and Quirke, 1979c, 48.5%, N = 171. However, Donald and Read (1967) report that 83.7% of 43 Finn lambs conceived at first oestrus and Dyrmundsson and Lees (1972a) found 73.1% of 26 Clun Forest Lambs to be pregnant following first service matings. Dyrmundsson (1973) cited additional references to confirm the generally low fertility of ewe lambs.

The superior fertility of cross-bred lambs at first service (+ 15.3%) and following all services (+ 5.5%) confirms other reports (Fox et al., 1964; Coop and Clark, 1965; Allison et al., 1975; Cedillo et al., 1977). West et al., (1973) report a significant effect of heterosis on ewe lamb fertility. Other reports on older ewes substantiate this (Botkin and Paules, 1965; Fox and McArthur, 1963). However, Hohenboken and Cochran (1976) reported a non significant 25% heterosis effect on ewe lamb fertility.

The higher fertility of twin-born over single-born lambs at first service (+ 10.2%) and following all services (+ 6.7%) was not significant. Holland and Ruttle (1966) found type of birth to have no effect on per cent lamb crop.

The finding that conception in marked ewe lambs was independent of autumn liveweight (first service and all services) confirms earlier reports that have shown small differences between autumn liveweights of conceiving and non-conceiving lambs (Keane, 1974c, 1975c; Gordon, 1967b).

An important finding in Experiment I was the significant regression of first service conception, per ewe lamb marked, on ewe lamb joining liveweight gain: between animal increases in joining liveweight gain were associated with decreasing conception rates. There appears to be no other reports in the literature on this relationship. The regression on pre- and post-laparotomy liveweight gains in

Experiment II proved non significant.

McGuirk, et al., (1968) report that 48%, 58% and 67% of mated lambs fed high (N = 56), medium (N = 37) and low (N = 21) planes of post-weaning nutrition respectively, actually lambed. The latter two groups gained a similar amount of liveweight over joining and the high plane group gained slightly less. It is possible that lucerne feeding prior to joining may have influenced that result as this feed was used, in part, to induce the pre-joining liveweight differences. Lucerne grazing has been shown to reduce litter size and fertility in older ewes following feeding around mating (McLeod, 1978).

It is difficult to explain this lowered fertility as a result of increasing liveweight gain. Ideally, information on insemination and ovulation failure would be needed before assessing the stage of reproductive wastage. At a minimum, all studies involving conception in ewe lambs should include in the design a procedure to determine if insemination has in fact occurred, before assessing the contribution of various factors to conception failure. In particular, experiments involving nutritional treatments should be aware of the indirect effect the feeding has on insemination failure as a result of increased ewe-ram contact at feeding times.

In view of the relatively high first service conception rates achieved in Experiment I, it is tempting to suggest that insemination failure was no greater than 10% and that differences in ovum viability accounted for the differences between lambs gaining varying liveweights over joining. However, confirmation both on a within-flock and between-flock basis is required before any firm conclusions can be drawn. If the current observations are verified, mating management of ewe lambs can be modified to increase chances of insemination and conception by mating in a confined area and restricting intakes and therefore liveweight gain.

Other studies show that pre-mating shearing can influence ewe lamb conception. Thus Gordon (1967b) reported 51.3% (N = 115) and 46.4% (N = 28) conception (all services) in oestrous shorn and unshorn Galway lambs respectively. Nedkvitne (1979) reports 83.8% of 80 shorn lambs conceiving (all services) compared to only 61.0% of 77 unshorn lambs. Since only all services information was recorded by both authors, the contribution of shearing to an increased proportion of shorn ewe lambs returning to service and conceiving should not be overlooked. Nedkvitne (1979) cited additional work to suggest higher all service conception rates in shorn compared to unshorn lambs.

In the light of these shearing effects, New Zealand studies should be initiated to find out the extent (if any) and causes of fertility responses to the pre-joining shearing of ewe lambs. Oestrous response, however, does not appear to be affected (Sumner, 1979).

Although indoor feeding of sheep is not a feature of New Zealand farming, the practice is not uncommon overseas. Bichard et al., (1974) indicate that housing Clun Forest lambs following mating can reduce fertility. These authors found premating supplementation to improve fertility in one experiment but reduce it in another. Clearly, more information is required on the causes of conception failure in ewe lambs.

Bowman (1966), amongst others, showed an improved lambing response with improved autumn liveweight. However, a proportion of the response would certainly be the result of an increased oestrous response at higher liveweights: a higher proportion of the lighter lambs would simply fail to mate.

If ewe lamb joining is to find increased application in New Zealand, then higher levels of fertility must be achieved: the causes of temporary sterility in the immature ewe need elucidating and remedial action taken to lessen this source of reproductive wastage.

VI.2.7 Ovum Survival

The notions of conception (pregnancy) and ovum survival are parallel for the majority of ewe lambs since few shed more than one ovum per oestrus. Few studies have investigated ovum survival using oestrous ewe lambs as donors and/or recipients of fertilized ova.

The similar ovum recovery rates for ewe lambs and ewes (Table 5-1) suggest that the rate of ovum transport, up until day 3 post coitum at least, is similar in the two groups. Quirke and Hanrahan (1977) report similar but lower (45 - 50%) recovery rates for ewe lamb and ewe ova. However, these authors recovered the reproductive organs following slaughter and transferred them to Thermos flasks prior to the laboratory flushings. The high ovulation rates in their super-ovulated sheep would have mitigated against the chances of high ovum recovery. Allison (unpublished) recovered three out of every four ova from ewe lambs in one trial, similar proportions from ewes and lambs in another (~ 64%) and 74% and 66% from ewe lambs and ewes respectively in another study. Allen and Lamming (1961b) recovered 60 - 66% of ova from slaughtered ewe lambs. These results suggest that ovum reception and transport within the upper reproductive tract is similar in mature and immature ewes.

In Experiment II, 4 of 16 ewe lambs from which ova were not recovered eventually lambed indicating that most unrecovered ova remain in the reproductive tract, largely no doubt the result of a poor flushing technique.

The fertilization rates of ewe lamb (91.4%) and ewe ova (90.5%) were high. Williams et al., (1978) reported a 97% fertilization rate for ewe lamb (10 - 12 months old) ova. Allen and Lamming (1961b) found that plane of rearing nutrition had little influence on ewe lamb ova fertilization rate (81 - 83%) in spite of a 10 kg difference in joining liveweight. Quirke and Hanrahan (1977) found 85.5% of ewe lamb and 78.0% of ewe ova to be fertilized. Allison (unpublished) reports a 94.4% ewe lamb ova fertilization rate in lambs known to have been inseminated at marking compared to 87.5% in a mob of marked lambs with no insemination information. Allison (unpublished) further reports 88.2% of lamb ova fertilized versus 97.1% of ewe ova. In yet a further unpublished report, Allison reports 89.8% of ewes compared to 91.2% of lamb ova fertilized. Hamma and Bryant (1979) report fertilization rates in excess of 90% in cross-bred lambs. These results suggest that age of ewe differences in ovum fertilization rates are not the major cause of fertility differences.

Unpublished work by Allison, involving singular homologous ovum transfers indicates a lower capacity for survival in ewe lambs compared to older ewes. From these transfers 81.8% of 33 ewes lambed compared to 46.7% of 15 ewe lambs ($P < 0.05$). Furthermore, results from inseminated but unoperated animals show that 53.8% of 26 lambs and 62.5% of 32 ewes lambed (Allison unpublished). Another experiment shows 82.4% of 51 ewes lambing compared to 55.7% of 61 lambs. Additional work with inseminated animals showed 76.3% of 97 ewes lambing compared to 69.0% of 58 lambs.

These trials indicate a higher level of reproductive wastage from fertilization to lambing in immature ewes than is apparent in older animals in New Zealand.

However, it was not established at this stage whether the source of additional wastage lay in the ewe lamb ovum, reproductive tract or both. In 1977 Irish workers (Quirke and Hanrahan) reported results of ovum transfer experiments involving the separate heterologous transfer of ewe and lamb ova to ewe recipients: 33.3% and 72.9% of 48 ewe lamb and ewe ova respectively, survived to term ($P < 0.01$). This result suggests that a large portion of the additional wastage could be accounted for by factors within the day 3 fertilized ewe lamb ovum. A similar result is indicated in Experiment II where, following the homologous transfer of ewe lamb ova and the coincident heterologous transfer of mature ewe ova ewe lamb ova (25.0%) were found to have approximately half the potential of mature ewe ova (52.5%) to survive to term. The lower survival rate of all ova suggests either a lower potential for the ewe lamb uterus to accommodate pregnancy, even when challenged with mature ewe ova, or that other experimental conditions were not conducive to high levels of ovum survival. The former is unlikely to be the case for several reasons. Allison (unpublished) reports ewe lamb ova survival rates of nearly double those currently presented. Quirke (1979b) reports almost identical conception (ovum survival) rates in ewes and ewe lambs following the singular transplantation of mature ewe ova. Furthermore, Quirke (1979b) was able to show comparable conception rates and litter sizes in ewes and ewe lambs following the transplantation of paired mature ewe ova (Table 6-1).

These results clearly indicate that ewes and ewe lambs have very similar capacities to support one or two pregnancies provided ova of 'normal' viability are used. The problem is therefore the viability of the ewe lamb ova. Whether the factors causing this lowered viability are inherent in the egg at or prior to ovulation; induced by conditions within the upper reproductive tract or a consequence of fertilization

TABLE 6-1 SURVIVAL OF FERTILIZED OVA FROM ADULT EWES IN THE UTERI OF ADULT EWES AND EWE LAMBS*
from Quirke (1979b)

Number of Fertilized eggs Transferred	Adult Ewes	Ewe Lambs
One fertilized egg:		
Number of recipient ewes	53	43
Number of barren ewes (%)	21 (39.6)	17 (39.5)
Number of lambing ewes (%)	32 (60.4)	26 (60.5)
Two fertilized eggs:		
Number of recipient ewes	64	34
Number of lambing ewes (%)	42 (65.6)	23 (67.6)
Number of single births (%)	13 (31.0)	9 (39.1)
Number of twin births (%)	29 (69.0)	14 (60.9)

* Unpublished results from Quirke and Hanrahan (1978)

remains unclear.

The limited available evidence suggests that development of the immature ewe ovum ceases prior to the blastocyst stage. In vitro studies with 4 - 7 month old lambs showed that while 72% of adult ewe eight-cell ova underwent at least one complete cleavage division in culture, only 50% of lamb eight-cell ova did so (Wright et al., 1976). Furthermore, no development past the early blastocyst stage (36 - 64 cell) was achieved by embryos collected from prepuberal ewes in any medium tested. Normality of development up to the morula stage (36 cells) has been demonstrated in four of six eggs transferred to the ligated rabbit oviduct (Trounson et al., 1977). These latter authors indicate that although the capacity of ovarian follicles from PMSG-primed lambs to secrete oestrogen, testosterone and progesterone in vitro was similar to that of follicles from adult ewes, oestrogen production by lamb follicles immediately after explantation was higher than that of adult follicles.

Quirke (1979a) observed anucleate particles at staining in both single cell and cleaved ova recovered from ewe lambs. These particles, which were regular in appearance, were often as large as individual blastomeres in cleaved ova and varied in number between 1 and 40. The significance of the presence of anucleate particles in sheep ova is uncertain. Killeen and Moore (1971) observed them in a high proportion of ova from mature Merino ewes but concluded that their presence did not preclude subsequent normal development. Tervit and McDonald (1969) did not appear to have observed such particles in observations of over 500 ova from mature Romney ewes. These latter authors, however, observed that cytoplasmic degeneration did occur in 40 - 60% of fertilized sheep ova following in vitro culture in sheep blood serum for 24 hours or more. Quirke (1979a) suggests the presence of anucleate particles in ewe lambs ova to be indicative of cytoplasmic degeneration.

The limited evidence from the current study indicates that the integrity of the zona pellucida is poorer in ewe lamb than ewe ova. This would be expected to limit subsequent development *in vivo*.

Other possibilities include aberrant maturation-ovulation-fertilization time relationships in the ewe lamb eventually leading to ovum degeneration.

Gurzav (1969) reports that ovulation occurs 15.2 hours after the onset of oestrus and within 1.5 - 4 hours of the end of oestrus. The finding that most ova were near the eight-cell stage when examined suggests that, relative to the onset of oestrus, ovulation, fertilization and cleavage rate are comparable in lambs and ewes.

Return to service intervals provide more clues as to the timing of the post-fertilization loss of ewe lamb ova (Edey, 1969). In Experiment I, 7 of the 28 (25%) intervals were longer than 20 days. These were 23 (2), 24, 30, 42, 44 and 55 days. These suggest that the loss occurs later than 10 - 12 days after marking (Edey, 1969). However, the information from Flock 2 lambs showed that 10 of 100 inter-oestrus intervals were also in excess of 20 days (χ^2_c = 2.66, P > 0.1). Thus not all of the ewe lambs returning to entire mating at intervals in excess of 20 days can be considered to have undergone delayed embryonic mortality. Edey *et al.*, (1978) concluded, on the basis of extended return to service intervals, that delayed embryonic mortality was a feature of infertility in ewe lambs.

Further evidence from Experiment II indicates that the majority of post-fertilization loss in ewe lambs occurs prior to day 10 - 12 *post coitum*. Thus, of 11 lambs returning to service following double transfers, only 2 (18.2%) did so at intervals in excess of 20 days.

These extended intervals were of 22 and 31 days duration.

These results should be considered somewhat conservative since some non-lambing ewes failed to return to service. The incidence of non-pregnant ewe lambs that did not return to oestrus was 22.7% of 22 lambs and 46.2% of 26 lambs in Experiments I and II respectively. The higher value for Experiment II lambs may, in part, be a result of the surgery and the fact that teaser rams remained with the lambs for a shorter post-mating period. Allison (unpublished) recorded 9.4% of 32 non-pregnant ewes failing to return to service compared to 82.2% of 45 non-pregnant ewe lambs. This latter value is close to the 86.3% of 124 non-pregnant ewe lambs in progestagen — PMSG treated Galway ewe lambs reported in Irish work (Quirke, 1979a) but in excess of the 51.2% of 84 Clun Forest lambs (Bichard et al., 1974). Both Allison and Quirke reported that the majority (50 - 65%)of non-pregnant, non-returning ewe lambs had lapsed into anoestrus within four weeks of mating (no corpora lutea observed) and an additional 18.9% (Allison) and 48.4% (Quirke) had corpora lutea. These latter ewes could have had anoestrual ovulations, persistent corpora lutea as a result of inadequate prostaglandin release from the uterus or delayed embryonic death. These considerations highlight the difficulty of obtaining precise estimates of early embryonic mortality in ewe lambs.

It is difficult to explain why a high proportion of non-pregnant ewe lambs fail to return to service. Perhaps some factor produced as a result of fertilization and/or early embryonic development supresses the gonadotrophic processes leading to oestrus and/or ovulation. An early pregnancy factor has been detected in adult sheep soon after fertilization (Nancarrow et al., 1980) but the role of this factor in subsequent reproductive events is unknown.

VI.2.8 Pregnancy Diagnosis

The ultra-sonic probe was the most accurate in determining pregnancy and barrenness (94.7%). This compares very favourably with the 95.1% reported by Keane (1969) for 41 adult ewes between 100 and 120 days of gestation. The only source of error in the current study, was the diagnosis of barrenness in 7 lambs which actually lambed. Keane (1969) recorded only two errors as a result of an ultrasonic method: one ewe diagnosed as pregnant failed to lamb and one ewe diagnosed as barren lambed. This author speculated that the first error, which was inconsistent with most literature reports, was due to a uterine inflammation or abnormality which gave rise to an audible sound characteristic of pregnancy. The false-negative diagnoses of pregnancy were most likely the result of incorrect placement of the probe on the abdomen within the two minute interval allocated. However, notwithstanding the inexperience of the operator, the current results were very satisfactory.

The use of tupping records was less accurate (87.1%) than the probe but still a satisfactory result. The 5 lambs that were diagnosed as pregnant but did not lamb, all failed to return to service. This phenomenon is not uncommon in ewe lambs (see earlier discussions). Of the 10 lambs incorrectly determined as barren, 4 were unmarked and were most likely mated during the two brief (< 24 hour) periods when harnessess were at fault (broken) during mating, and 6 were marked during 'pregnancy'. A retrospective appraisal of the tupping records indicated that 5 of these 6 ewe lambs could be attributed with tupping dates in line with their lambing dates. It would therefore appear that oestrus during pregnancy was not a feature of immature ewes. However, Bichard et al., (1974) reported this phenomenon in 19 ewe lambs and suggested that the use of a ram to detect barren ewe lambs was unreliable.

In general, the results from the current study support this view.

Knight et al., (1979) investigated the identification of barren ewes using vasectomized rams and found: 1. of the total barren ewes, 29.6% (range 18.2% - 46.6%) in one flock and 48.0% (range 31.3% - 66.9%) in another flock were marked in the 4 weeks after joining; 2. the percentage of barren ewes marked by teasers increased with ewe prejoining liveweight; 3. breed of ewe differences were small and year differences large; and 4. 0.6% - 1.2% of pregnant ewes were marked by rams. These results with mixed age ewes further highlight the limitations in detecting barrenness using harnessed rams.

The efficiency of visually assessing pregnancy or barrenness was unsatisfactory (79.5%) and highlights one of the practical problems faced by the commercial producer following ewe lamb matings. Operator variation can account for some of the discrepancy (Asofi, unpublished) but results can still be unsatisfactory (Keane, 1969). Although all ewes determined pregnant eventually lambed there was close to a 40% chance of barren ewes lambing. Thus assessments of pregnancy tended toward the conservative. As indicated previously, a reassessment immediately prior to the commencement of lambing resulted in the correct identification of the 27 cases of false-negative barrenness.

It terms of the practicalities of the three methods, daily tupping records involved the greatest labour input. This could be overcome to some extent by weekly or fortnightly recordings, although some loss in efficiency would be expected. The use of harnessed rams for the identification of pregnant and barren ewe lambs would be the least favoured of the three.

Although very good results can be achieved using an ultrasonic device, consideration would have to be given to the availability of equipment and technical assistance as well as costs associated with the use of the service or purchase of equipment. Where the service is available at reasonable cost this method would be the most favoured.

Although visually appraising ewe lambs for pregnancy yielded the poorest all round results, improvements could be achieved by using experienced operators and reassessing 'barren' lambs some 2 - 3 weeks later. This low cost method would currently be the most widely used in New Zealand for identifying pregnant and barren sheep 4 - 6 weeks prior to lambing.

VI.2.9 Behaviour and Milk Potential Score

These results confirm the superior maternal ability of BLX sheep. Dalton (1974) reports that 81% of Coopworth and 78% of Romney ewes sought shelter at lambing. Furthermore, this author reported that 85% of Coopworths were excellent mothers versus only 58% of Romney dams.

The milk potential of BLX lambs at birth was marginally better overall than Romney lambs. The scoring system largely assessed udder volume. Both Linzell (1966) and Davis et al., (1980) have shown high correlations between udder volume and milk production in adult goats and sheep respectively. It is not known whether the small breed differences in udder volume at term accounted for the advantage to BLX lambs for daily gain to weaning.

VI.2.10 Fleece Production

The superior wool production for one-year-old BLX lambs over Romney lambs has been demonstrated in other studies (Hight and Jury, 1971). These two authors demonstrate large differences (0.4 - 0.6 kg) even when considered at the same shearing liveweight. The extent to which heterosis affected these results is unknown but believed to be small (Rae and Wickham, 1970).

The small birth rank effect is within the range (0.05 - 0.2 kg) reported by Hight and Jury (1971) who show that most of the birth rank effect is attributable to differences in shearing liveweight.

The finding that Flock 1 and 2 animals clipped similar fleece weights is in accordance with many other reports (e.g. Lewis, 1959; Canon and Bath, 1969; Baker et al., 1978). It is clearly shown that pregnancy per se has no effect on fleece weight. The inferior wool production in ewe lambs that failed to cycle has been previously demonstrated in Romneys (Ch'ang and Raeside, 1957).

VI.2.11 Lambs Weaned

The 65% incidence of marked ewes rearing a lamb is disappointing when compared to performances achieved with older ewes. The 35% wastage was due almost equally to ewes failing to lamb (54%) and lambed ewes failing to rear lambs (46%). Since ewe lambs invariably have only one lamb, high levels of lamb survival and conception are of paramount importance in achieving a high weaning rate.

The advantage to BLX and twin-born ewes was largely a reflection of conception rate differences.

The overall measure of reproductive efficiency, lambs weaned per ewe joined, was disappointing at a mean of 58%. This variable was marginally higher for BLX than Romney genotypes. Coop and Clark (1965) recorded larger breed differences in one-year-old ewes of these genotypes, particularly in the year of lower joining liveweights (+ 18% versus + 28%). The values recorded in the current study were intermediate between the two years data recorded by Coop and Clark (1965).

Of the 41.7% of joined ewe lambs not weaning a lamb, failure to be marked accounted for approximately 26%, 33% was due to lambs dying prior to weaning and failure to lamb following mating accounted for the remaining 41%. With mating seasons of 3 to 4 weeks duration, failure to show oestrus would be expected to account for an increasingly larger share of the proportion of joined ewes not weaning a lamb (somewhere around 50%). This highlights the importance of attaining high autumn liveweights and successful mating management to ensure that all oestrous lambs are mated.

The following hypothetical example illustrates the weaning rate possible following a 21 day ewe lamb joining period for a 100 animal flock under very good conditions:

Number Joined	= 100	
Number Mated	= 85	
Number Lambing	= 68	(assumes 80% marked ewes lamb)
Number Lambs Born	= 75	(assumes 10% of lambing ewes twin)
Lambs Weaned	= 60	

Lambs Weaned per 100 ewe lambs joined = 60%.

Thus, a 60% weaning rate could be considered the maximum achievable under optimum conditions with the major genotypes currently available. Failure to mate, failure to conceive following mating and failure to wean a lamb following lambing would respectively account for approximately 40%, 35% and 25% of the difference from a 100% weaning rate.

The importance of genotype and nutrition in promoting a high oestrous response have been discussed earlier. The mating of ewe lambs under intensive conditions - small paddocks; high ram:ewe ratios; active, fertile, dexterous rams - will ensure that very few oestrous ewe lambs will go unmated and furthermore, that insemination failure is almost eliminated.

Research into the causes of reduced immature ewe ovum viability may lead to improvements in the ovum survival rate in both immature and mature ewes. The fact that ovum survival is higher in mature ewes than ewe lambs suggests that this infertility is only transitory and the result of some factor(s) associated with immaturity. Bryant and Hamra (1980) have recently shown that lambs fed to achieve either a high or low mean liveweight at mating were equally likely to have live embryos at slaughter 25 days after mating. Furthermore, although lambs then fed a 75% maintenance level for 25 days *post coitum* were less likely to have live embryos at slaughter than lambs fed a 150% maintenance ration, the differences were not significant (H-H 48%; H-L 40%; L-H 50%, L-L 41%). These results suggest that post-weaning and post-mating nutrition do not have large effects on conception failure in ewe lambs. However, more definitive work with large numbers of animals is required

VI.3 Ewe Lamb Progeny Performance

VI.3.1 Prenatal Growth

The mean gestation length in Experiment I (144.2 days) was some 2.4 days shorter than recorded in Experiment II. This may have been the result of the Southdown breed of sire and/or a year effect. Included in the year effect would be the fact that the ewes were pre-lamb shorn in Experiment I but not Experiment II. Larsen (1971) and Eastwood (1975) obtained lengths of around 147 days in two-year-old Romney and BLX ewes mated to Southdown sires and Boshier *et al.*, (1969) obtained a similar result in three-year-old Romney ewes carrying single Romney lambs. It is therefore unlikely that the shorter lengths in Experiment I were directly attributable to the Southdown genotype. The results of the two-year-old ewe lambings indicate that this particular generation of ewes may experience shorter gestation periods than would be expected from earlier generations in the same flock.

Gordon (1967b) recorded a mean gestation length of 145.3 days (N=12) in single-born lambs born to one-year-old Suffolk-cross ewes. This was some 2.5 - 3.0 days shorter than recorded for single-born lambs born to adult ewes in the same study. The present findings are in accord with other findings which indicate increasing mean gestation lengths in older ewes (see Dyrmundsson, 1973).

The mean day of birth was October 7 and 4 in Experiments I and II respectively. These are some 4 - 5 weeks later than would be expected from older ewes in this district. The management implications of this later lambing include: 1. the increasing workload on farms at this time is further compounded; 2. these lambs are lighter than lambs born to older ewes by 5 - 6 kg at weaning; and 3. spring pasture growth rate increases can coincide with lambing and lead to lambing problems associated with heavier birth weights. However, this latter point was not found to be a problem in the South Island (Lewis, 1959) in one particular year. The later mean birth date in that study (October 19) reflects later matings also observed in older ewes in New Zealand associated in part with increasing latitude (Quinlivan and Martin, 1971a).

Lamb birth weights in Experiment I were almost 1 kg heavier than in Experiment II. However, although the lower birth weight of twin- compared to single-born lambs contributed to most of the difference, 0.3 kg still remained between single lambs born to Romney dams in each experiment. This variation could be attributed to sire breed effects (Carter, 1968) or year effects (Dalton et al., 1980). The finding that BLX dams gave birth to heavier lambs than Romney dams in Experiment I is consistent with reports for single-born lambs born to two-year-old (Eastwood, 1975, 0.22 kg) and older ewes (Hight and Jury, 1970, 0.14 kg).

The mean birth weight in Experiment I is similar to those reported for mixed-age ewes (Hight and Jury, 1970; Dalton et al., 1980) and highlights the ability of the ewe lamb uterus to adequately support a large foetal mass. Most reports support the finding in Experiment II that the progeny of one-year-old ewes are generally much lighter at birth than the progeny of older dams (see Dyrmundsson, 1973). This may be indicative of a greater impetus to partition available nutrients to maternal bodyweight gain rather than to the products of conception in the immature ewe.

The sex of lamb effect on birth weight was small in both experiments. This suggests an inter-action with age of dam as most reports with adult ewes indicate quite large differences in favour of male lambs (Hight and Jury, 1970, 0.23 kg; Dalton et al., 1980, 0.3 kg; Eastwood, 1975, 0.35 kg).

The finding that twin-born lambs are lighter than single-born lambs at birth is widely reported. However, the difference of almost 1 kg in Experiment II is much larger than commonly reported for older ewes' progeny but is similar to the difference between twin- and triplet-born lambs (Eastwood, 1975). However, twin-born lambs from one-year-old Romney dams can be 0.7 - 0.8 kg heavier than those in the current study (Lewis, 1959). The relationship of birth weight to lamb survival will be discussed in a later section.

VI.3.2 Postnatal Growth

The superior liveweight performance of BLX lambs was evident at all weighings (Figure 4 - 10). This breed effect was constant at approximately 4 kg from November 30. The results from both Eastwood (1975) and Hight and Jury (1970) support these findings.

A part of the breed effect was undoubtedly due to differences in birth day since BLX lambs were 7 days older at all weighings. No adjustments were made for this difference since it was considered part of the breed effect. An important finding was that of significantly different breed regressions of liveweight on day of birth (or age at weighing) at several of the weighings (i.e. November 9, 30; January 11 and February 1). Since these further complicate the interpretation of breed differences, any such differences in liveweights at these weighing times should be cautiously interpreted. The larger regressions for BLX compared to Romney lambs is indicative of the greater growth rate of BLX lambs. For the latter three weighings mentioned above, the regression of liveweight on age in Romney lambs was positive although not significantly different from zero indicating that differences in age at weighing had no significant effect on liveweight. This would suggest that later born lambs grew faster than earlier born lambs. It remains unclear as to why this should occur to a greater extent in Romney than BLX lambs. The inconsistent importance of this interaction between breed and age at weighing is also difficult to explain.

The effect of weaning on November 30 rather than December 21 was to reduce post-weaning daily gain by approximately 50g/day over this period. Furthermore, the daily gain of the later weaned group over the next 21 day period was superior to the earlier weaned lambs indicating that early weaning effects were carried over for at least six weeks.

The superior post-weaning daily gain of Late Weaned lambs indicates that Early Weaned lambs suffered permanent reductions in growth rate under the drought conditions of Experiment I.

The significant breed by sex by group interaction makes interpretations of main effect differences difficult. It is probable that chance occurrences associated with low numbers of animals could explain some of the interactions. However, it seems as though breed and sex differences have been deflated while group differences have been inflated. Jagusch et al., (1970) have reported no differences in liveweight up to 12 weeks of age in lambs weaned onto lucerne pastures at 3 - 5 weeks compared to unweaned lambs. This result was consistent in both twin- and single-born lambs. Furthermore, Furnival and Corbett (1976) indicate that the greater the liveweight of lambs at six weeks (when early weaned) the greater was the difference between sucklings and weanlings at 12 weeks. The suitability of lucerne as an early weaning diet was also stressed by these authors.

More information is required to assess whether breed differences exist in their responses to early weaning and if the response is further modified by the post-weaning level of nutrition.

VI.3.3 Survival

The mean lamb survival rates in Experiment I and II were within the range of 76 - 87% reported by Dalton et al., (1980) for several breeds of adult ewes run under hill country conditions. Neither of the lamb genotype differences were significant in each of Experiment I and II, although lambs with a more cross-bred genotype were more likely to survive.

Lamb survival was higher for female than male lambs, particularly in Experiment II. This is in agreement with the published literature. The physiological reasons for this are unclear but Dalton et al., (1980) showed that sex of lamb differences remained significant when considered at the same birth weight.

The survival of twin-born lambs was very low and highlights an aspect of the unacceptability of twinning in immature ewes. The low survival rate of twin-born lambs born to one-year-old ewes has been reported in other studies (Lewis, 1959, 53.6%, n=28; Gordon, 1967b, 45.5% n=22). Hight and Jury (1970) and Dalton et al., (1980) show that birth rank differences in lamb survival can be largely accounted for by birth weight differences. However, Atkins (1980) reported that birth rank differences remained significant when considered at the same birth weight.

The small number of lambs in Experiment II probably contributed to the lack of a significant relationship between lamb survival and birth weight.

Of the four lambs assisted at birth in Experiment I, three died prior to weaning compared to three out of six in Experiment II.

The causes of death were undiagnosed since post-mortem examinations were not carried out. However, the settled weather over lambing in both years, the developed maternal behaviour of the vast majority of post-parturient ewe lambs and the timing of most deaths within 12 - 24 hours of birth suggest that the fault lay within the newborn lamb. Lamb vigour at birth appeared poor in most lambs that died subsequent to tagging.

The higher survival of single-born lambs in Experiment II compared to Experiment I is interesting and suggests an effect unrelated to birth weight. Dalton et al., (1980) showed that most of the variation between years remained after allowance for birth weight differences between years. Furthermore, if the conclusion from that New Zealand work could be applied to the current study, most of the difference between the lamb survival of progeny from immature and mature ewes would be accounted for. Dalton et al., (1980) showed that age of dam effects (2 - 5 years) had largely disappeared when considered at the same birth weight.

McCall (1980) found that the progeny survival of ewe lambs born as triplets exceeded that of ewe lambs reared of lesser rank. This suggests a positive phenotypic relationship between fecundity background and lamb survival at one year of age.

The effects of factors that increase lamb survival either indirectly, through birth weight or directly require investigation so that the survival of immature ewe progeny can be increased. In this regard, Gordon (1967b) has shown that prejoining shearing of ewe lambs can lead to increases in single-born lamb birth weight (+ 0.4 kg) and survival (+ 17.4%). When viewed along with the conception advantages of this management option, the urgeny for confirmatory New Zealand research is obvious. The extent to which birth weight and lamb survival can be influenced by varying the feeding level remains unclear. Robinson et al., (1971) and Quirke et al., (1978) reported that lamb birth weights were higher on a lower plane of nutrition and the latter authors reported higher survival rates as well. Hight and Jury (1970) and Dalton et al., (1980) also note conflicting evidence on this point.

Rams whose progeny have either high or low survival rates in some environments may rank otherwise in other environments (Knight, 1977). Breed of sire rankings may differ with age of ewe. Therefore, several sire breeds require evaluation for this trait when with ewe lamb mates. In this regard, Perendale (Dalton et al., 1980),'easy-care' Romney (Hight, 1978) and 'Waihora' Romney (Hight et al., 1975) rams should be evaluated against the Southdown breed for progeny survival and growth performance. It is possible that the birth weight of Southdown sired lambs is below the optimum for high lamb survival when mated to immature ewes.

VI.4 Two-year-old Ewe Performance

VI.4.1 Onset of Breeding Season

The mean date of onset (March 13) is some two weeks earlier than reported for Romney ewes by Till (1950). Dyrmundsson (1978) reported seasonal variations of a similar magnitude in young Icelandic ewes.

Furthermore, correlation coefficients between body weight and the onset of breeding activity in these Icelandic ewes were low and none were significant. Although Drew et al., (1973) reported that ewes fed moderately over their second spring-summer came into oestrus 9 days earlier than sheep gaining weight more rapidly, both Till (1950) and Wallace (1961) were unable to alter onset to any great extent by premating nutrition.

The finding in the current study that BLX ewes were in oestrus earlier than Romney ewes is consistent with the report of Hight et al., (1976). However, two-year-old ewes in that study were in oestrus some three to four weeks later than currently reported. Quinlivan and Martin (1971a) showed that increases in altitude and latitude can play a part in delaying first oestrus in ewes.

The slightly earlier onset in twin-born ewes is consistent with the higher level of reproductive performance expected from these ewes. Furthermore, the similar mean dates of onset for Flock 1 and 2 ewes support earlier overseas findings (Canon and Bath, 1969; Keane, 1974b).

The finding that Infertile ewes came into oestrus some 1 - 2 weeks earlier than other classes of ewe is interesting. No other workers appear to have reported this effect. If real, and confirmation by further experimentation is required, the result suggests that attempts to select two-year-old ewes that show early oestrus may indirectly lead to reduced fertility in ewe lambs. Conversely, the culling of ewe lambs that are marked but fail to lamb could lead to a delay in the mean date of onset in two-year-old ewes. The physiological basis for this effect is unknown. It could be that some factor carried over from ewe lamb mating influences the responsiveness of the two-year-old ewe to those factors involved in initiating onset of the subsequent breeding season.

The later onset in Acyclic ewes is consistent with the lower reproductive performance expected from this class of ewe (Hulet et al., 1969; Moore et al., 1978).

VI.4.2 Oestrous Cycle Length

The mean interval between oestruses of 16.6 days was slightly more than the 16.2 days recorded by Eastwood (1975) for two-year-old ewes not receiving gonadotrophin. The small difference between BLX and Romney ewes, although statistically significant, is of little practical significance. This difference could have arisen as a result of increased circulating progesterone in the higher ovulating BLX ewe (Thorburn et al., 1969) as this steroid has been shown to be associated with increased cycle lengths (Lamond et al., 1972).

It is interesting to note that birth rank, flock and class effects on cycle length were all small.

VI.4.3 Multiple Ovulation

The mean incidence of multiple ovulation (40%) is within the range reported in several other New Zealand studies involving two-year-old ewes (Eastwood, 1975, 30%; Hight and Jury, 1976, 16 - 50%; Moore et al., 1978, 12 - 55%). The advantage to BLX ewes (+ 25%) is similar to that reported by Eastwood (1975), + 24%, but less than that reported by Hight and Jury (1976), +(32 - 34%). The regression of the incidence of multiple ovulation on joining liveweight was positive for both genotypes but significant for BLX ewes only. Thus, the advantage to BLX ewes would be expected to increase as the joining liveweight difference between ewes of each breed increased. This results suggests that increasing joining liveweight of BLX ewes, by improved nutrition for example, is likely to improve ovulation rate more than a similar liveweight gain in Romney ewes. Information is required on a between-group basis before this can be validated. Eastwood (1975), however, did not record a significant breed by nutrition interaction on ovulation rate in two-year-old ewes.

The odds ratio multiplicative factor for BLX ewes of 1.192 per kg increase in joining liveweight (Class model) is within the range (1.162 - 1.209) derived from data reported by Smith et al., (1979) for mixed-age Coopworth ewes on a within-treatment group basis. Cockrem (1979) has reviewed the literature on liveweight-reproduction relationships and presented several hypotheses on the physiology of the relationships.

The incidence of multiple ovulation was similar in both flocks inspite of the 3 kg difference in joining liveweight in favour of Flock 2 ewes.

Although the proportion of multiple ovulations ranged from 27% to 54%, the small numbers of animals in the classes precluded significant differences. The incidence of multiple ovulation in Weaned ewes (Classes 1 and 2) was slightly less (-4%) than for Oestrous ewes. This was expected as a result of the lighter joining liveweight (- 5 kg) of these ewes.

The high incidence of multiple ovulation in Acyclic ewes, probably a reflection of only a small number of ewes, is contrary to the low ovulation rates recorded for this class of ewe as two-year-olds (Hight and Jury, 1976; Moore et al., 1978) in other studies.

VI.4.4 Conception

The 84% conception to first service is considered excellent for two-year-old ewes mated in drought conditions. This is higher than the 66% reported by Eastwood (1975) for similar ewes.

Breed differences in first service conception rate were small. This agrees with earlier results from the same flock (Eastwood, 1975) but is at variance with those recorded at ewe lamb joining when BLX lambs out performed Romney lambs (see earlier discussion).

Interestingly, first service conception rates of those ewes which had earlier conceived at ewe lamb matings (Classes 1, 2 and 4) were higher than those which had not conceived to earlier matings (Class 6, Table 4-31). This suggests that ewe lamb fertility (or infertility) is to some extent repeatable at the two year stage. However, first service conception rate was poorer in Flock 1 compared to Flock 2 ewes, an effect consistent within four of the five component classes. The causes of this transient infertility, particularly in those ewes that had previously weaned lambs, remains unclear. The lack of a large number of return to service intervals in excess of 18 days in these ewes implicates fertilization failure or early embryonic mortality. Hence, of the 25 ewes not conceiving to first service, 2 (one Early Weaned and one Infertile) did not return at all, and 4 (one Early Weaned, 33 days; one Late Weaned, 24 days; one Oestrous, 35 days and one Infertile, 28 days) returned at intervals greater than 18 days. It is difficult to account for the higher apparent fertilization failure/early embryonic mortality in Flock 1 ewes, particularly those ewes that had previously weaned lambs. Perhaps lactation in the immature ewe leads to a temporary infertility as a result of a shorter duration of oestrus making insemination less likely, impairment of sperm and/or ovum transport or; a uterine environment which has not returned to a state capable of supporting pregnancy. Williams et al., (1978) suggest that ovum fertilization and the survival of fertilized ova may be reduced in older ewes that had been weaned for 6 but not 11 weeks. However, most of the weaned ewes in the current study would have been unsuckled for at least 12 weeks by joining time.

Clearly, the infertility in previously suckled ewes was only transient since only 1 out of 74 failed to lamb following subsequent services.

The difference between flocks in first service conception rate can be almost totally accounted for by differences in conception rate between single ovulating ewes since flock differences in multiple ovulating ewes were small. Furthermore, the difference between Infertile and other ewes could largely be accounted for by the differences in first service conception rate of the single ovulating ewes.

Although numbers of ewes are small, it appears as if lactation, but not necessarily pregnancy, in the ewe lamb can lead to infertility at first service at the two-year-old mating in single but not multiple ovulating ewes. More information is required to define the physiological basis for this result.

The conception rate of single ovulating ewes was not significantly less than for multiple ovulating ewes (81.8% versus 92.3%). This accords with other reports in the literature (Killeen, 1967; MacKenzie and Edey, 1975; Eastwood, 1975). Such findings are almost automatic since multiple ovulating ewes can lose one ovum and remain pregnant whereas pregnancy would be terminated in single ovulating ewes.

The proportion of ewes lambing following all services was high (96.4%) and similar in both breeds. However, all six barren ewes were from Flock 1. Furthermore, three of these were Infertile ewes. This suggests that some tract abnormality may have prejudiced pregnancy in these ewes. This remains speculative as no laparotomies were carried out on these ewes. However, all six were known to have ovulated at the first entire mating.

Other reports have indicated small differences in the subsequent lambing rate of ewes treated similarly to Flocks 1 and 2 (Spencer et al., 1942; Canon and Bath, 1969; Keane, 1974b; McCall 1980).

The use of conception information at the ewe lamb stage to predict conception results at the two-year-old stage does not appear to be precise enough according to the results of this study. However, the generally low fertility, at two years of age, in animals that were infertile as ewe lambs suggests a cause common to both ages.

Quinlivan et al., (1966a) found that 6% of parous and 15% of non-parous rising three-year-old ewes showed some genital tract abnormality which may have influenced fertilization of ova.

VI.4.5 Ovum Survival

Approximately 20% of all corpora lutea were not represented by lambs at term. This is at the lower end of the range reported for ovum mortality following fertilization (Edey, 1969). There was only a small difference in ovum mortality between single (18.2%) and multiple ova (20.8%). This contrasts with work by Casida et al., (1966) who report a 23.6% mortality rate in single ovulators whereas 34.2% of twin ovulations were not represented by embryos. The present result suggests that twin ovulators are far less susceptible to total loss than single ovulators although Edey (1966) reported contrary results following severe nutritional restriction in early pregnancy.

The incidence of partial failure of multiple ovulation was higher amongst Romney (18%) than BLX ewes (10.0%). Thus, not only were twin ovulating BLX ewes more likely to support pregnancy compared to twin ovulating Romney ewes, they were also less likely to lose one of the two possible embryos. The reason for this is not clear. However, Larsen (1971) reported small differences in the ability of two-year-old Romney and BLX ewes to accommodate three transferred ova. Furthermore, ovum survival was independent of ovum genotype (Romney or BLX) in that study.

The mean incidence of partial failure of multiple ovulation (13.1% of multiple ova or 28.3% of pregnant ewes) is similar to those reported by Kelly and Allison (1976): 28% - 36% of pregnant ewes, but lower than estimates reported by Quinlivan et al., (1966a): 43% and 47% of pregnant ewes. Australian work with Corriedales has indicated that 15% - 20% of April joined twin ovulating ewes lose one embryo (Davis et al., 1976). The causes of partial failure are largely unknown although the majority of partial losses occur before or about day 18 of pregnancy (Edey, 1969). Bishop (1964) suggests that much of the loss is unavoidable and needed to eliminate unfit genotypes.

The incidence of partial failure is not greatly affected by flock. Although the numbers of ewes involved is small, it is interesting to note that the incidence is very low in Early Weaned ewes (13.3%)

Two out of three multiple ovulating ewes gave birth to two lambs (71.7% of lambing ewes). The latter figure compares favourably with the 64% - 72% reported by Kelly and Allison (1976) and the 71 - 80% reported by Davis et al., (1976) but exceeds the 47% and 55% reported by Quinlivan et al., (1966a).

The high proportion of twin ovulating BLX ewes giving birth to twins is further confirmation of the superior ability of this genotype to retain a high proportion of multiple ovulated ova (85% in this study). Twin ovulating Romney ewes could retain only 70% of these ova (χ^2_c = 0.692, P > 0.1).

The high incidence of twinning in Early Weaned ewes is further proof that pregnancy and lactation in the ewe lamb need not lead to a lowering of two-year-old reproductive performance. Quinlivan et al., (1966a,b) arrived at a similar conclusion when evaluating the effects of two-year-old parity on three-year-old performance.

VI.4.6 Lambs Born Per Ewe

The mean litter sizes (% lambs born per ewe lambing) of 1.30 and 1.27 for ewes lambing following first service and all services respectively lie within the 19% - 51% multiple birth rate range (% ewes lambing multiples per ewe lambing) reported by Dalton and Rae (1978) for two-year-old Romney ewes in several studies.

Although BLX ewes had a higher litter size than Romney ewes breed differences were largely accounted for by differences in joining liveweight. Several other workers have reported a positive dependence of multiple birth rate (e.g. Coop and Hayman, 1962; Drew et al., 1973; Hight and Jury, 1976) and litter size (e.g. Coop, 1973; Joyce et al., 1976) on joining liveweight.

Litter size in Early Weaned ewes exceeded that in Oestrous ewes. This was largely a reflection of the small multiple ovulation rate difference between these groups.

The mean number of lambs born per ewe joined was 1.11 and 1.23 following first service and all services respectively. These are similar to the 1.01 and 1.28 values reported for two-year-old ewes by Goot (1951) and Hart and Stevens (1952) respectively.

BLX ewes gave birth to more twins and fewer singles per ewe joined compared to Romney ewes. However, when considered at the same liveweight, the advantages to BLX ewes were never significant. The incidence of twinning per ewe joined increased with increasing liveweight whereas the incidence of single births declined.

The number of lambs born per ewe joined was slightly lower in Flock 1 ewes (1.08 versus 1.19, first service; 1.22 versus 1.26, all services). These small differences were largely the result of more ewes lambing in Flock 2.

When all ewes that had previously reared a lamb are considered, their litter size (1.25) was almost identical to that achieved in Oestrous ewes. Spencer <u>et al.</u>, 1942; Canon and Bath, 1969; and Levine <u>et al.</u>, 1978, amongst others, report that parity in the ewe lamb can lead to small reductions in two-year-old litter size. The present findings do not confirm these earlier reports. However, other workers indicate increases in litter size as a consequence of ewe lamb parity (Suiter and Croker, 1970; Tyrell et al., 1974; McCall, 1980).

VI.4.7 Lambs Weaned Per Ewe

The incidence of lambing ewes which lost all their lambs was slightly lower following first service than all services (17.5% versus 19.1%). This was largely a reflection of the very low litter size in ewes that returned to service. The latter figure is more than twice the 8% (range over years 7.4% - 8.9%) recorded in mixed-age Romney ewes

(Quinlivan and Martin, 1971a). Quinlivan and Martin (1971b) subsequently reported a mean value of 8.4% in stud flocks.

There was a small advantage to cross-bred ewes in the incidence of lambing ewes which failed to wean any lambs. Of more importance is the finding that more Flock 2 than Flock 1 ewes failed to wean any lambs. The small number of animals involved probably accounts for the lack of statistical significance. The major factor leading to the lower incidence of failure to wean ewes in Flock 1 ewes was the performance of ewes that had previously reared lambs. Thus 13.7% of these ewes failed to rear any lambs compared to 24.4% and 27.8% of Oestrous and Infertile ewes respectively. Although flock differences were smaller when joined ewes were considered, the performance of ewes that had previously reared lambs was superior to that of ewes that only showed oestrus. Differences in lamb survival, which will be discussed later, were an important factor in explaining this result.

McCall (1980) reports that, at two years of age, ewes which previously reared a lamb weaned more lambs per ewe present at lambing than either ewes that lambed but failed to rear a lamb and ewes failing to lamb at one year (0.958 versus 0.863 versus 0.823 respectively. Baker et al., (1978) report small differences in lambs weaned per ewe lambing at two years between ewes that had shown oestrus as ewe lambs but were not permitted to lamb and ewes actually lambing at one year (1.30 versus 1.24, respectively). However, in direct contrast to the performance of Infertile ewes, comparable ewes in Baker's work performed the best at two years of age. The reasons for this are unclear although those authors suggest that errors of recording may have lead to incorrect groupings.

Thus, it seems clear that parity in the ewe lamb need not depress the ratio of lambs weaned per ewe joined at the two year stage, and can, as this study has shown, lead to improvements if early weaning is practiced.

VI.4.8 Fleece Weight

Unjoined ewes produced more wool than Joined ewes. However, there were significant interactions between breed and class for February and Cumulative fleece weights. Thus, whilst weaning group had neglible influence on the fleece weight of Romney ewes, the difference was significant for BLX ewes. It is unlikely that the short period of extra suckling by Late Weaned BLX ewes could account for this difference. It seems plausible that the effect was one of chance whereby heavier fleeced BLX ewes were probably allocated to the Early Weaned group.

However, the finding that suckling as a ewe lamb reduced February fleece weight relative to Oestrous ewes was consistent in both breeds (0.5 kg in Romney, 0.3 - 0.5 kg in BLX ewes). However, the effect was not carried over to the November shearing. These results are consistent with the published literature which shows that lactation in the ewe lamb reduces fleece weight but the effect is only temporary (e.g. Baker et al., 1978; Ponzoni et al., 1979).

The effect of lactation when one-year-old on February fleece weight accounts for most of the difference in Cumulative fleece weight between Early and Late Weaned, and Oestrous ewes.

VI.5 Two-year-old Ewe Progeny Performance

VI.5.1 Birth Weight

The mean birth weight of 4.15 kg is heavier than those recorded for two-year-old ewe progeny in several other New Zealand studies (Hight and Jury, 1970: 3.64 kg; Larsen, 1971: 3.51 kg; Eastwood, 1975: 3.74 kg; Dalton et al., 1980: 3.3 kg). Some of the differences could probably be accounted for by year effects. Dalton et al., (1980) reported a range of mean birth weight from 3.4 - 4.2 kg between years.

The similarity of mean birth weights at one and two years of age in this study is interesting. Most reports indicate an increase with dam age (Dalton et al., 1980). The extent to which pre-lamb shearing increased birth weights in 1977 is unclear. Shearing is known to increase voluntary intake of ewes (Wodzicka-Tomaszewska, 1963) and increase lamb birth weights (Austin and Young, 1977).

Although breed differences for single-born lambs were very small, twin-born BLX lambs were heavier than twin-born Romney lambs. This indicates that the environment provided by Romney ewes (maternal and genetic) did not restrict the potential prenatal growth of lambs until at least two were present. Larsen (1971) found that the Romney maternal environment restricted the prenatal growth of single-born Romney as well as BLX lambs. The current results suggest that the prenatal nutrient pool becomes limiting in Romney ewes before it does in BLX ewes.

The finding that male lambs were heavier than female lambs (0.2 kg) is consistent with the bulk of published literature (e.g. Hight and Jury, 1970: 0.23 kg; Eastwood, 1975: 0.35 kg; Dalton et al., 1980: 0.3 kg). The physiological basis for this is unclear.

Although the effect of flock on lamb birth weight was small in the present study, other reports indicate both positive (McGloughlin and Crowly, 1971) and negative effects (Canon and Bath, 1969; Keane, 1974b). It seems likely that some of the differences can be accounted for by the relative proportions of the various classes of ewe involved in the joined flock. This study highlights the low birth weights of progeny from ewes failing to cycle as ewe lambs (Acyclic ewes) and the inconsistent ranking of single- and twin-born progeny from ewes infertile as ewe lambs (Infertile ewes). Furthermore the current results indicate that pregnancy as well as lactation in one-year-old ewes have only small positive effects on the birth weights of the two-year-old crop of lambs.

VI.5.2 Gestation Length

The mean gestation length of 145.9 days was lower than those recorded by Larsen (1971) and Eastwood (1975) of 146.5 and 146.7 days respectively. However, Boshier et al., (1969) recorded even longer lengths in three-year-old Romney ewes (147.2 days). Although an increase in gestation length with increasing ewe age is indicated, the matter is unresolved (Forbes, 1967). The shorter gestation lengths recorded for one-year-old ewes in the current study supports the belief that younger sheep do have shorter gestation periods (Dyrmundsson, 1973).

The longer gestation period for BLX ewes was not in accord with other results for two-year-old BLX and Romney ewes from this same flock (Larsen, 1971; Eastwood, 1975). Both of these workers record Romney ewes carrying lambs for approximately one day longer than BLX ewes. However, the breed by sex by flock inter-action in the current study precludes definitive conclusions, although the longer gestation period for BLX genotypes was also evident in one-year-old ewes.

Terrill (1944) recorded that litter size had little or no effect on the duration of gestation. The current findings support this and other work (Boshier et al., 1969; Larsen, 1971; Eastwood 1975).

The independence between gestation length and sex of lamb has been clearly demonstrated (Terrill, 1944; Forbes, 1967; Larsen, 1971; Eastwood, 1975).

Although flock differences were not significant, they depend on litter size. Thus Flock 1 ewes carried single lambs longer than Flock 2 ewes but the situation was reversed in twinning ewes.

Although the numbers of animals is not large, the shorter gestation lengths of Acyclic ewes is consistent in single- and twin-bearing ewes and suggests that this effect is real. There appears to be no other published information to confirm this.

VI.5.3 Birth Day

Differences in birth day are largely a result of differences in day of conception rather than differences in gestation length.

The only significant difference was birth rank - twins were born about 5 days earlier than single lambs. This is consistent with the report by Knight and Hight (1976) who indicated a decreasing multiple birth rate in ewes mated later in the joining season. This is probably the result of decreasing ovulation rates associated with progression through the breeding season (Averill, 1964; McDonald and Ch'ang, 1966; Kelly et al., 1976) rather than a seasonal influence on partial or total failure of multiple ovulation.

The mean lambing date of August 19 contrasts with the later lambing date for one-year-old ewes (October 7, Experiment I: October 4, Experiment II). This point is of practical significance (see earlier discussion) and is often cited as one of the disadvantages of lambing in one-year-old ewes.

VI.5.4 Postnatal Growth

Differences in weaning weight paralleled differences in daily gain to weaning. The superior weaning weight of BLX, male and single-born lambs compared to Romney, female and twin-born lambs respectively is consistent with other reports (Hight and Jury, 1971; Larsen, 1971; Eastwood, 1975). However, the performance of lambs born as twins but reared as singles is higher than expected. However, this result should be interpreted with caution since a small number (N=10) of lambs were available to estimate the effect.

Lactation in the ewe lamb clearly has no effect on weaning weight of the two-year-old crop of lambs. This is consistent with the report of McGloughlin and Crowley (1971) who found that although ewes in their second lactation, when two-year-olds, produced 0.41 kg per day more milk than ewes in their first lactation at this age, differences in early growth rate of the twin lambs reared by the two groups of ewes were almost identical. The low correlation between milk yield and lamb growth rate (r=0.14) in that study was probably due to the small numbers of animals involved.

The low weaning weight for the progeny of Acyclic ewes is a further indication of the inferior performance of this class of ewe.

Thus, the current findings clearly show that lactation in the immature ewe has no carry over effects on the weaning weight and growth rate of lambs born the following year.

VI.5.5 Survival

The survival rate of all lambs (82.6%) is greater than reported for the progeny of two-year-old ewes from several other New Zealand studies (Hight and Jury, 1970; Dalton et al., 1980). Both of these studies showed that survival increased with age of dam.

The lower survival rate of lambs born to Romney ewes is a consistent finding (Hight and Jury, 1970; Dalton et al., 1980) particularly when joined with Romney rams (Meyer and Clarke, 1978). Dalton et al., (1980) report that most of the age of dam but not breed effects on lamb survival are removed following adjustment to the same birth weight. The Southdown sire breed has been shown to result in higher lamb survival rates compared to other prime lamb sire breeds (Carter, 1968) when mated to Romney ewes. This may account for the relatively high lamb survival rate reported in the current study.

Female lambs were more likely to survive than male lambs, a factor previously discussed.

The survival advantage to lambs born to two-year-old ewes that had previously lambed and/or reared lambs is consistent with several other findings. Thus, McCall (1980) reports two-year-old ewes' lamb survival rates of 83.8%, 84.4% and 88.2% respectively for ewes that did not lamb, lambed but failed to rear the lamb, and reared one lamb, when one-year-old. Canon and Bath (1969) report 94% and 92% lamb survival at birth in flocks comparable to Flocks 1 and Flock 2 in the current study. Baker et al., (1978) report superior lamb survival at the two year lambing for ewes that had lambed at one year compared to ewes that only displayed oestrus, particularly in the Steigar breed.

It has also been shown in three-year-old ewes that the ability to lamb (Quinlivan et al., 1966a) and to rear lambs (Dalton et al., 1980) the previous year can lead to improved lamb survival rates. Thus Dalton et al., (1980) reported survival rates of 73%, 79% and 84% at three years respectively for ewes that were barren, lambed but fail to rear a lamb, and reared a lamb, as two year olds. Furthermore, the difference between barren and previously parous dams remained even after adjusting to a common birth weight (Dalton et al., 1980).

The basis for these parity and lactation influences on lamb survival the following year is unknown. However, Apps (1953) and Kilgour (1978) maintain that parity in the one-year-old ewe can lead to a lower incidence of dystocia and better mothering ability at two years of age. Both factors could lead to improvements in lamb survival. Without information on the timing and causes of death in lambs born to two-year-old ewes that were previously parous or suckled, it is difficult to account for the difference.

However, it is clear, whatever the mechanism, that lamb survival is enhanced in two-year-old ewes if they have previously experienced a lambing or lactation. This advantage can more than compensate for the reduction in litter size often observed at the two-year-old lambing in previously suckled ewes.

APPLICATIONS TO INDUSTRY

CHAPTER VII

APPLICATIONS TO INDUSTRY

It is important to consider the practice of mating ewe lambs as a means of increasing the scale, as well as the biological and economic efficiencies of lamb production. Apart from the wool they grow, ewe lamb replacements do not contribute to productivity. However, lambing at approximately one year of age increases the amount of product over which the maintenance costs of the ewe is spread. This is essentially the same principle involved in justifying twinning in older ewes. It is calculated (Sykes, unpublished) that in a flock with 120% lambing and four lambings per ewe, only 2.5% of the herbage energy consumed and available to the animal is converted to energy in the lamb carcass. However, this can be increased by 20% if the ewe had weaned a lamb when 14 - 16 months old. If reliable reproduction at this stage could be achieved without subsequent loss of performance, the increase in efficiency would be equivalent to an increase in lambing percentage from 120% to 145%. Clearly, this is equivalent to the genetic progress which might be achieved by many years of intensive selection for fecundity within a flock, and can be achieved within approximately 8 months of joining.

In practice, the effect of the number of lambs weaned by immature ewes on the increase in flock weaning percentage (that is, lambs weaned per ewe joined for ewes two years and older) is the product of ewe lamb weaning percentage and the ratio of ewe lambs to mixed-age ewes. Thus, in a 1000 ewe flock supported by 300 joined ewe lambs which wean 100 lambs, the increase in flock weaning percentage would be $(^{300}/_{1000}) \times (\frac{100}{300}) \times \frac{100}{1} = 10\%$. This result is similar to that achieved by almost a decade of selection or by mean increases in ewe joining liveweights of 4 - 5 kg.

A critical requirement for successful ewe lamb reproduction is the attainment of a mean target joining liveweight of at least 35 kg. This requires a mean birth to joining daily gain in the order of 0.150 kg. If lambs weigh 20 - 25 kg at weaning, then mean rates of post-weaning daily gain in the order of 0.100 kg are required. Jagusch et al., (1979) report that allowances of between 2 and 5 kg dry matter (DM)/lamb/day are necessary to promote early post-weaning gains of 0.100 - 0.150 kg/day.

Although it is satisfactory to join all ewe lambs, the practice of leaving light lambs unjoined would effectively increase the ram:ewe ratio. However, it is unlikely that such lambs would be marked over the joining period if they had not been withheld.

It would seem advisable that joining not extend for more than 21 days, particularly for farmers who have had only a limited experience with the practice. This would enable the evolution of a management system that could cope with such a practice. As experience is gained, joining could be extended to 4, 5 or even perhaps 6 weeks. However, it should be remembered that higher weaning percentages are likely to follow these extended joining seasons with a compounding of management problems to the point that breeding ewe numbers might have to be reduced. The economic and management implications of this would therefore require careful evaluation.

In view of the findings that ewe lambs show a shorter and less intense heat than older ewes, it is advisable to: 1. join no more than 50 lambs per ram; 2. choose the smaller of the available rams; 3. mate lambs apart from older ewes; 4. mate in paddocks which are small and flat; and 5. use rams which are active and dexterous. Furthermore, a prejoining crutching of ewe lambs would be advisable if prejoining shearing is not carried out. Prejoining shearing (autumn shearing) of ewe lambs is not carried out to any extent in New Zealand, although overseas results indicate improvements in both the oestrous response and fertility of marked ewe lambs. A management advantage of this practice is that the spring shearing can be delayed or perhaps replaced by an earlier two-year-old ewe prejoining shearing. In view of the increased conception failure rate of ewes shorn over or after mating, it is unadvisable to shear ewe lambs at this stage.

The use of earlier maturing prime lamb breeds of sire as mates is advisable. Black faced rams would be a husbandry aid as it is unlikely that lambs from these ewes would be used for breeding replacements and colour marking would save confusion.

The available evidence indicates that increasing the level of nutrition over joining above that required for maintenance is unlikely to influence fertility. Although they require confirmation, results from the current study indicate that moderate rather than high gains over joining result in improved fertility.

In view of the unreliable results often achieved following the use of ram harnesses over and subsequent to joining, it is probably not necessary to use these as a means of determing pregnant ewe lambs. However, the use of harnesses over entire joining can give some indication of the extent of oestrous activity. If the mating season is of 21 days duration, it can be expected that 60% - 70% of these marked ewe lambs would eventually lamb.

Winter management of the pregnant ewe lamb is no different from that for barren ewe lambs. Thus, winter liveweight gains need only be moderate as the demands of the developing foetus are small over the first 100 days of pregnancy.

During the last six weeks of pregnancy the nutritional demands of the foetus is such that additional feeding must take place if optimum lamb birth weights, maximum lamb survival and a minimum rate of assistance at lambing is to be achieved. Thus, pregnant ewe lambs should be identified and grazed separately from non-pregnant ewe lambs. They should be fed to achieve increases in liveweight in the order of 8 kg - 10 kg over this final six weeks of pregnancy. It is advisable to pre-lamb shear pregnant ewe lambs at least one month before lambing so that the risk of pregnancy toxaemia is minimized. It is also important that additional feed be available in the few days immediately after shearing.

Since it appears that ewe lambs make excellent mothers, minimal disturbance over lambing would also have the advantage of lowering the labour input over this period.

Lactating ewe lambs should be fully fed so as to ensure that they continue to gain liveweight and produce sufficient milk to promote high levels of progeny daily gain. Since these two factors become increasingly incompatable as lactation proceeds, some compromise has to be reached between weaning lambs at a young age and ensuring that two-year-old ewe joining liveweights are only marginally reduced. The important point to remember is that these lambs are a bonus that have been achieved at a very low cost. Thus, weaning should occur at a mean lamb age of 50 - 60 days. If preweaning growth rates have been good (at least 0.250 kg/day) the mean weaning weight of lambs would be close to 20 kg. Clearly, only a small proportion of these lambs are likely to be prime at weaning. The decision as to whether the weaned lambs should be retained or disposed of at this time would no doubt depend on feed supply and market conditions about this time. Ideally, returns would be maximized if all lambs were sold prime.

Ewe lambs can be expected to be 40 - 45 kg at weaning. They therefore require to grow at approximately 0.150 kg/day to achieve a satisfactory two-year-old joining liveweight. Lactation will have reduced ewe lamb liveweights by approximately 5 kg at weaning.

If subsequently grazed with non-suckled ewe lambs approximately half of this difference will have been compensated for by two-year-old joining. It is possible to compensate for all of the liveweight difference if suckled ewe lambs are preferentially grazed between weaning and the next joining. However, this involves a greater management input along with the provision of additional feed. Although only a small proportion of suckled ewe lambs would be expected to rear twins, it is advisable that these be preferentially fed over lactation and/or the post-weaning period.

Suckled ewe lambs can be expected to clip 0.2 - 0.3 kg less wool at the two-year-old prejoining shearing. Subsequent fleece production is however, unaffected.

If suckled ewe lambs are 2 - 3 kg lighter at the two-year-old joining only negligible differences in fertility and fecundity can be expected. However, since lamb survival is improved in the progeny of previously suckled ewes no reduction in lambs weaned per ewe joined is expected. Lamb weaning weights at this time are unaffected by ewe lamb suckling. Furthermore, ewe liveweight differences attributable to ewe lamb suckling are not expected to persist beyond the two-year-old weaning stage.

Although there is little New Zealand information on the effects of ewe lamb suckling on lifetime performance and longevity, overseas results indicate little subsequent effect up until six years of age at least.

Table 7-1 contains gross margin analyses for the replacement ewe lambs of a 1000 ewe flock for which a gross margin analysis is outlined (Appendix VI). In all cases, costs and prices are assumed to be those ruling during the 1980/81 farming season. Under the conditions assumed in these analyses, reflective of moderate North Island hill country sheep farming, the percentage increase in gross margin per ewe for a 1000 ewe flock is 2.1%, 5.4%, 8.6% and 11.9%

TABLE 7-1 GROSS MARGIN PER 450 EWE LAMBS

Assumptions: Southdown rams x Romney ewe lambs
Are replacements ewe lambs for case outlined in Appendix VI
2% rams joined with all ewe lambs and used for 4 years
Two-year-old reproductive performance is unaffected by a previous suckling.

	Weaning Performance (Lambs Weaned per Ewe Lamb Joined)			
	20%	40%	60%	80%
Gross Revenue:				
Lambs @ $12.00 net	$1080	$2160	$3240	$4320
Direct Costs:				
Animal Health @ $0.50	$ 45	$ 90	$ 135	$ 180
2.25 Rams @ $100	$ 225	$ 225	$ 225	$ 225
Ram capital cost - 9 rams @ $100 @ 12%	$ 108	$ 108	$ 108	$ 108
Reduced Two-year-old Performance:				
0.3 kg wool @ $2.65 net	$ 72	$ 144	$ 216	$ 288
Gross Margin Per 450 ewe lambs:	$ 630	$1593	$2556	$3519
Increase in Gross Margin over case shown in Appendix VI	2.1%	5.4%	8.6%	11.9%

for a 20%, 40%, 60% and 80% weaning performance by the 450 ewe lambs joined with rams. The gross margins are applicable to the situation where stocking rate is such that there is a surplus of feed supplies over the August to November period. Over the months of August, September, October and November the increases in dry matter intake are in the order of 30%, 40%, 40% and 75% respectively (see Appendix VII). The additional feed consumed by the pregnant/lactating ewe lamb and its lamb is approximately 50% more than consumed by a non-pregnant ewe lamb over these four months. If suckled ewe lambs are grazed with the remaining ewe lamb flock from weaning and all progeny are disposed of at weaning, the 80 kg of extra dry matter consumed will be the only additional feed required for the pregnant/lactating ewe lamb and its offspring. This amount may be marginally reduced since the suckled ewe lambs will be lighter after weaning and therefore have a lower maintenance requirement.

In conclusion, the practice of joining entire rams with ewe lambs for a restricted period can lead to respectable increases in productivity and profits. Such a practice would be low cost and could be confidently applied to many more sheep farming enterprises than is currently the case.

SUMMARY

SUMMARY

The objectives of this investigation were to examine the effects of reproduction in the ewe lamb on two-year-old performance of Romney and BLX genotypes and furthermore, to test the hypothesis that increased embryonic mortality is an important factor in explaining the low fertility of Romney ewe lambs.

Although the incidence of oestrus was similar in both genotypes, BLX ewe lambs were more fertile. Since there were only small genotypic differences in litter size and lamb survival, the BLX dams weaned more lambs as one-year-olds. The progeny of BLX dams remained in utero longer, were heavier at birth, were born earlier and grew faster than the progeny of Romney dams. Furthermore, BLX ewe lambs grew more wool, were heavier, exhibited better mothering instincts and had larger udders at parturition than Romney ewe lambs

As two-year-old ewes, BLX compared to Romney ewes commenced oestrous activity earlier and had higher multiple ovulation rates, litter sizes and weaning percentages. They also grew more wool and produced lambs which were more likely to survive and grew faster to weaning. Compared to ewes that had only been marked by vasectomized rams as ewe lambs, those that reared lambs were similar in their commencement of oestrous activity, cycle lengths, all services conception rate, litter size, November fleece production and progeny gestation length and birth weights. Furthermore, liveweight, multiple ovulation rate, first service conception rate, ovum survival and February fleece weight were reduced while lamb survival was markedly increased and more heavier lambs were weaned per ewe joined.

These results indicate that reproduction in the ewe lamb can lead to an increased weaning performance at the two-year-old stage with a small decrease in fleece weight. Improved lamb survival was an important factor in obtaining this advantage.

Differences between ewe lambs and ewes were small for ovum recovery, fertilization and transfer rates. Insemination failure was negligible in marked ewe lambs. Some ewe lambs were anovular at oestrus while none of the ewes exhibited this phenomenon. The post-fertilization ovum survival rate of ewe lamb ova was half that of mature ewe ova, following the transfer into ewe lambs. This confirmed the hypothesis that reduced ewe lamb ovum viability is a major factor in explaining the lower fertility characteristic of the immature Romney ewe. There is an urgent need to identify and eliminate those factors responsible for this if the potential fertility of ewe lambs is to be achieved.

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APPENDICES

APPENDIX IA: EFFECT OF BREED, BIRTH RANK AND FLOCK ON EWE LIVEWEIGHT: APRIL - JULY, 1977

	Weighing Date			
Classification	Mean ± S.E. Liveweight (kg)			
Breed of Ewe	April 29	May 27	June 24	July 22
Romney	33.7 ± 0.7	37.3 ± 0.7	37.9 ± 0.7	34.9 ± 0.7
BLX	39.0 ± 0.5	42.3 ± 0.5	43.9 ± 0.5	41.4 ± 0.5
Birth Rank				
Single	37.0 ± 0.8	40.2 ± 0,8	41.1 ± 0.8	37.9 ± 0.9
Twin	35.1 ± 0.6	38.9 ± 0.6	40.1 ± 0.6	37.9 ± 0.7
Flock				
Joined	36.3 ± 0.9	40.2 ± 0.9	41.0 ± 0.9	38.2 ± 1.0
Unjoined	35.8 ± 0.8	37.9 ± 0.8	39.6 ± 0.8	37.0 ± 0.9

Continued . . .

EFFECT OF BREED, BIRTH RANK AND FLOCK ON EWE LIVEWEIGHT:

AUGUST - NOVEMBER 9, 1977

Classification	Weighing Date			
	Mean ± S.E. Liveweight (kg)			
Breed of Ewe	August 19	September 16	October 21	November 9
Romney	35.6 ± 0.7	38.6 ± 0.9	41.3 ± 0.7	44.6 ± 0.8
BLX	42.7 ± 0.5	46.5 ± 0.7	47.2 ± 0.5	50.0 ± 0.6
Birth Rank				
Single	39.0 ± 0.9	42.3 ± 0.9	44.2 ± 0.9	47.8 ± 0.9
Twin	38.7 ± 0.7	42.2 ± 0.8	43.5 ± 0.6	46.2 ± 0.7
Flock				
Joined	39.4 ± 1.0	43.5 ± 1.2	44.2 ± 1.0	46.7 ± 1.0
Unjoined	37.5 ± 0.9	38.8 ± 1.0	43.4 ± 0.8	48.4 ± 0.9

Continued . . .

EFFECT OF BREED, BIRTH RANK AND FLOCK ON EWE LIVEWEIGHT:

NOVEMBER 30 - FEBRUARY 1, 1978

Classification	Weighing Date			
	Mean ± S.E. Liveweight (kg)			
Breed of Ewe	November 30	December 21	January 11	February 1
Romney	46.8 ± 0.9	48.3 ± 1.0	49.4 ± 1.0	50.1 ± 1.0
BLX	52.5 ± 0.6	54.1 ± 0.7	55.5 ± 0.8	56.7 ± 0.8
Birth Rank				
Single	50.3 ± 1.0	51.9 ± 1.1	53.2 ± 1.1	53.9 ± 0.9
Twin	48.4 ± 0.7	49.8 ± 0.8	51.0 ± 0.9	52.2 ± 0.9
Flock				
Joined	48.9 ± 1.1	50.0 ± 1.2	51.1 ± 1.3	52.2 ± 1.3
Unjoined	51.3 ± 0.9	54.1 ± 1.0	55.7 ± 1.1	55.9 ± 1.1

Continued . . .

EFFECT OF BREED, BIRTH RANK AND FLOCK ON EWE LIVEWEIGHT:

FEBRUARY 22 - MAY 10, 1978

Classification	Weighing Date			
	Mean ± S.E. Liveweight (kg)			
Breed of Ewe	February 22	March 15	April 12	May 10
Romney	48.3 ± 1.0	48.0 ± 0.9	46.5 ± 0.9	45.9 ± 0.9
BLX	55.3 ± 0.7	55.5 ± 0.7	54.2 ± 0.7	53.4 ± 0.6
Birth Rank				
Single	52.2 ± 1.1	51.9 ± 1.1	50.4 ± 1.1	50.0 ± 1.0
Twin	50.8 ± 0.8	50.7 ± 0.8	49.6 ± 0.8	48.7 ± 0.8
Flock				
Joined	50.6 ± 1.2	50.7 ± 1.2	49.5 ± 1.2	48.7 ± 1.2
Unjoined	54.4 ± 1.1	53.8 ± 1.1	51.8 ± 1.1	51.4 ± 1.0

Continued . . .

EFFECT OF BREED, BIRTH RANK AND FLOCK ON EWE LIVEWEIGHT:

JULY 19 - NOVEMBER 22, 1978

Classification	Weighing Date Mean ± S.E. Liveweight (kg) July 19	November 22
Breed of Ewe		
Romney	50.8 ± 0.9	57.1 ± 1.1
BLX	58.4 ± 0.7	63.5 ± 0.8
Birth Rank		
Single	54.6 ± 1.1	60.9 ± 1.2
Twin	53.9 ± 0.8	59.0 ± 0.9
Flock		
Joined	53.7 ± 1.3	59.5 ± 1.3
Unjoined	55.9 ± 1.1	61.6 ± 1.2

APPRENDIX IB: EFFECT OF BREED, BIRTH RANK AND FLOCK ON EWE LIVEWEIGHT: APRIL - JULY, 1977

ANOVA

Source of Variation	d.f.	Mean Square			
		April 29	May 27	June 24	July 22
Breed	1	1178.88***	1024.79***	1497.90***	1768.66***
Birth Rank	1	179.45**	108.56*	74.59*	3.15
Flock	1	22.59	216.20***	99.86*	54.52
Breed x Flock	1	65.48†	20.59	89.02*	101.52*
Breed x Birth Rank	1	15.10	6.44	18.20	3.58
Birth Rank x Flock	1	30.13	58.03†	33.25	93.53*
Breed x Birth Rank x Flock	1	2.58	4.09	4.32	23.41
Error	158	18.41	20.32	17.97	21.76
Total	165				

Continued . . .

EFFECT OF BREED, BIRTH RANK AND FLOCK ON EWE LIVEWEIGHT:

AUGUST - NOVEMBER 9, 1977

ANOVA

Source of Variation	d.f.	Mean Square			
		August 19	September 16	October 21	November 9
Breed	1	2059.37***	2671.39***	1420.71***	1227.83***
Birth Rank	1	19.31	26.29	56.74	86.22+
Flock	1	141.52**	747.21***	42.46	60.95
Breed x Flock	1	167.45**	173.93*	17.73	13.38
Breed x Birth Rank	1	3.57	0.05	6.05	30.30
Birth Rank x Flock	1	43.90	19.37	9.75	17.41
Breed x Birth Rank x Flock	1	5.20	24.08	14.37	10.87
Error	158	21.07	29.05	21.30	26.75
Total	165				

Continued . . .

EFFECT OF BREED, BIRTH RANK AND FLOCK ON EWE LIVEWEIGHT:

NOVEMBER 30 - FEBRUARY 1, 1978

ANOVA

Source of Variation	d.f.	Mean Square			
		November 30	December 21	January 11	February 1
Breed	1	1315.30***	1397.97***	1521.28***	1761.55***
Birth Rank	1	124.70*	110.20†	121.97†	73.37
Flock	1	122.78*	430.15***	557.72***	336.28**
Breed x Flock	1	1.33	0	0	12.45
Breed x Birth Rank	1	17.43	10.52	11.91	5.41
Birth Rank x Flock	1	11.52	18.81	2.09	20.15
Breed x Birth Rank x Flock	1	15.23	8.50	12.28	12.55
Error	158	29.91	36.45	41.78	43.37
Total	165				

Continued . . .

EFFECT OF BREED, BIRTH RANK AND FLOCK ON EWE LIVEWEIGHT:

JULY 19 - NOVEMBER 22, 1978

<u>ANOVA</u>

Source of Variation	d.f.	Mean Square	
		July 19	November 22
Breed	1	2371.93***	1692.15***
Birth Rank	1	9.61	123.79
Flock	1	121.30†	94.26
Breed x Flock	1	2.69	18.99
Breed x Birth Rank	1	35.42	4.19
Birth Rank x Flock	1	8.03	49.72
Breed x Birth Rank x Flock	1	0.26	18.59
Error	158	36.64	45.89
Total	165		

APPENDIX II: EFFECT OF BREED AND CLASS ON EWE LIVEWEIGHT APRIL 29, 1977.

Classification	Mean ± S.E. Liveweight (kg) Breed of Ewe		
Class	Romney	BLX	Both Breeds
1. Pregnant	34.4 ± 1.1a	39.8 ± 1.7	37.1 ± 1.2
2. Oestrous	35.1 ± 1.8a	37.7 ± 1.9	36.3 ± 1.3
3. Acyclic	28.2 ± 2.0b	38.9 ± 2.3	32.2 ± 1.6
4. Infertile	33.4 ± 1.9a	37.5 ± 1.6	34.8 ± 1.1
All Classes	33.7 ± 0.7	39.0 ± 0.5	

ANOVA

Source of Variation	d.f.	Mean Squares
Breed	1	1044.96***
Class	3	85.85**
Breed x Class	3	63.15*
Error	158	17.562
Total	165	

Continued . . .

EFFECT OF BREED AND CLASS ON EWE LIVEWEIGHT MAY 27, 1977.

Classification	Mean ± S.E. Liveweight (kg)
Breed of Ewe	
Romney	37.4 ± 0.7
BLX	42.3 ± 0.5
Class	
1. Pregnant	40.9 ± 1.2a
2. Oestrous	38.3 ± 1.4bc
3. Acyclic	35.8 ± 1.7c
4. Infertile	39.7 ± 1.1ab

ANOVA

Source of Variation	d.f.	Mean Square
Breed	1	924.22***
Class	3	130.15***
Breed x Class	3	49.21†
Error	158	19.355
Total	165	

Continued . . .

EFFECT OF BREED AND CLASS ON EWE LIVEWEIGHT JUNE 24, 1977.

Classification	Mean ± S.E. Liveweight (kg)		
	Breed of Ewe		
Class	Romney	BLX	Both Breeds
1. Pregnant	38.4 ± 1.7a	45.0 ± 1.7a	41.7 ± 0.1
2. Oestrous	38.6 ± 1.8a	41.6 ± 1.8b	40.0 ± 0.1
3. Acyclic	32.6 ± 2.0b	43.1 ± 2.3ab	36.5 ± 0.2
4. Infertile	39.2 ± 1.9a	43.4 ± 1.5ab	40.6 ± 0.1
All classes	37.9 ± 0.7	43.9 ± 0.5	

ANOVA

Source of Variation	d.f.	Mean Square
Breed	1	1384.91***
Class	3	100.32***
Breed x Class	3	63.17**
Error	158	16.817
Total	165	

Continued . . .

EFFECT OF BREED AND CLASS ON EWE LIVEWEIGHT JULY 22, 1977.

Classification	Mean ± S.E. Liveweight (kg)		
	Breed of Ewe		
Class	Romney	BLX	Both Breeds
1. Pregnant	35.5 ± 1.8a	43.0 ± 1.8a	39.3 ± 1.3
2. Oestrous	35.8 ± 1.9a	39.4 ± 2.0b	37.5 ± 1.5
3. Acyclic	29.2 ± 2.2b	38.8 ± 2.5ab	32.8 ± 1.8
4. Infertile	35.5 ± 2.1a	39.1 ± 1.7ab	36.7 ± 1.2
All Classes	34.9 ± 0.7	41.4 ± 0.5	

ANOVA

Source of Variation	d.f.	Mean Square
Breed	1	1586.73***
Class	3	150.96***
Breed x Class	3	60.18*
Error	158	19.694
Total	165	

Continued . . .

EFFECT OF BREED AND CLASS ON EWE LIVEWEIGHT AUGUST 19, 1977

Classification	Mean ± S.E. Liveweight (kg) Breed of Ewe		
Class	Romney	BLX	Both Breeds
1. Pregnant	36.6 ± 1.7a	44.5 ± 1.7a	40.6 ± 1.3
2. Oestrous	36.5 ± 1.9a	39.7 ± 1.9b	38.0 ± 1.5
3. Acyclic	29.2 ± 2.0b	40.0 ± 2.4ab	33.3 ± 1.8
4. Infertile	35.7 ± 2.0a	41.3 ± 1.6b	37.6 ± 1.2
All Classes	35.6 ± 0.7	42.7 ± 0.5	

ANOVA

Source of Variation	d.f.	Mean Square
Breed	1	1827.22***
Class	3	207.56***
Breed x Class	3	72.71**
Error	158	18.249
Total	165	

Continued . . .

EFFECT OF BREED AND CLASS ON EWE LIVEWEIGHT SEPTEMBER 16, 1977

Classification	Mean ± S.E. Liveweight (kg)		
	Breed of Ewe		
Class	Romney	BLX	Both Breeds
1. Pregnant	41.3 ± 1.9a	49.8 ± 1.9a	45.6 ± 1.5
2. Oestrous	37.4 ± 2.0b	41.4 ± 2.1b	39.3 ± 1.6
3. Acyclic	31.1 ± 2.3c	42.0 ± 2.6b	35.2 ± 2.0
4. Infertile	37.1 ± 2.2bd	43.2 ± 1.8b	39.1 ± 1.3
All Classes	38.6 ± 0.9	46.5 ± 0.7	

ANOVA

Source of Variation	d.f.	Mean Square
Breed	1	2203.86***
Class	3	653.81***
Breed x Class	3	65.15*
Error	158	21.658
Total	165	

Continued . . .

EFFECT OF BREED AND CLASS ON EWE LIVEWEIGHT: OCTOBER 21, NOVEMBER 9, 1977.

Classification	Mean ± S.E. Liveweight (kg) October 21	November 9
Breed of Ewe		
Romney	41.3 ± 0.7	44.5 ± 0.8
BLX	47.2 ± 0.5	50.0 ± 0.6
Class		
1. Weaned	44.5 ± 1.3a	45.7 ± 1.4a
2. Oestrous	43.8 ± 1.4a	48.9 ± 1.5b
3. Lamb Died	46.0 ± 1.8a	48.9 ± 1.9ab
4. Acyclic	40.3 ± 1.8b	44.7 ± 1.9a
5. Infertile	44.1 ± 1.2a	48.7 ± 1.2ab

ANOVA

Source of Variation	d.f.	Mean Square October 21	Mean Square November 9
Breed	1	1385.15***	1366.59***
Class	4	71.53**	152.77***
Breed x Class	4	43.3†	39.17
Error	156	19.506	23.744
Total	165		

continued . . .

EFFECT OF BREED AND CLASS ON EWE LIVEWEIGHT NOVEMBER 30, 1977.

Classification	Mean ± S.E. Liveweight (kg)
Breed of Ewe	
Romney	46.8 ± 0.9
BLX	52.5 ± 0.6
Class	
1. Early Weaned	47.8 ± 1.6a
2. Late Weaned	46.8 ± 1.6a
3. Oestrous	51.7 ± 1.6b
4. Lamb Died	52.1 ± 2.0b
5. Acyclic	48.3 ± 2.0ab
6. Infertile	51.7 ± 1.3b

ANOVA

Source of Variation	d.f.	Mean Square
Breed	1	1563.43***
Class	5	210.08***
Breed x Class	5	46.24†
Error	154	24.558
Total	165	

Continued . . .

EFFECT OF BREED AND CLASS ON EWE LIVEWEIGHT DECEMBER 21, 1977.

Classification	Mean ± S.E. Liveweight (kg)		
	Breed of Ewe		
Class	Romney	BLX	Both Breeds
1. Early Weaned	43.8 ± 2.3a	53.7 ± 2.2a	49.2 ± 1.7
2. Late Weaned	43.6 ± 2.2a	48.7 ± 2.2b	46.3 ± 1.7
3. Oestrous	52.0 ± 2.2b	57.4 ± 2.2a	54.9 ± 1.6
4. Lamb Died	54.1 ± 2.5b	56.7 ± 2.8a	55.0 ± 2.0
5. Acyclic	45.6 ± 2.5a	56.8 ± 2.8a	49.8 ± 2.0
6. Infertile	51.6 ± 2.3b	57.6 ± 1.9a	53.6 ± 1.3
All Classes	48.3 ± 1.0	54.1 ± 0.7	

ANOVA

Source of Variation	d.f.	Mean Square
Breed	1	1771.130***
Class	5	453.228***
Breed x Class	5	54.80*
Error	154	25.169
Total	165	

Continued . . .

EFFECT OF BREED AND CLASS ON EWE LIVEWEIGHT JANUARY 11, 1978.

Classification	Mean ± S.E. Liveweight (kg)		
	Breed of Ewe		
Class	Romney	BLX	Both Breeds
1. Early Weaned	44.0 ± 2.4a	54.6 ± 2.3a	49.8 ± 1.8
2. Late Weaned	44.6 ± 2.3a	49.3 ± 2.3b	47.1 ± 1.7
3. Oestrous	53.6 ± 2.3b	59.2 ± 2.3c	56.3 ± 1.7
4. Lamb Died	55.4 ± 2.6b	58.3 ± 2.9ac	56.5 ± 2.1
5. Acyclic	46.9 ± 2.6a	59.0 ± 2.9ac	51.4 ± 2.1
6. Infertile	53.1 ± 2.4b	60.4 ± 2.0c	55.5 ± 1.4
All Classes	49.4 ± 1.0	55.5 ± 0.8	

ANOVA

Source of Variation	d.f.	Mean Square
Breed	1	1984.44***
Class	5	565.354***
Breed x Class	5	68.982*
Error	154	27.462
Total	165	

Continued . . .

EFFECT OF BREED AND CLASS ON EWE LIVEWEIGHT FEBRUARY 1, 1978.

Classification	Mean ± S.E. Liveweight (kg)		
	Breed of Ewe		
Class	Romney	BLX	Both Breeds
1. Early Weaned	45.3 ± 2.5a	56.3 ± 2.5a	51.3 ± 1.9
2. Late Weaned	45.1 ± 2.5a	51.4 ± 2.4b	48.4 ± 1.8
3. Oestrous	53.7 ± 2.4b	59.3 ± 2.5a	56.4 ± 1.8
4. Lamb Died	56.0 ± 2.7b	59.1 ± 3.1a	57.2 ± 2.2
5. Acyclic	48.1 ± 2.7a	61.2 ± 3.1a	53.0 ± 2.2
6. Infertile	54.0 ± 2.6b	59.6 ± 2.1a	55.9 ± 1.5
All Classes	50.1 ± 1.0	56.7 ± 0.8	

ANOVA

Source of Variation	d.f.	Mean Square
Breed	1	2213.06***
Class	5	449.996
Breed x Class	5	74.094
Error	154	30.867
Total	165	

Continued . . .

EFFECT OF BREED AND CLASS ON EWE LIVEWEIGHT FEBRUARY 22, 1978.

Classification	Mean ± S.E. Liveweight (kg)
Breed of Ewe	
Romney	48.3 ± 1.0
BLX	55.3 ± 0.7
Class	
1. Early Weaned	50.0 ± 1.8a
2. Late Weaned	47.3 ± 1.8a
3. Oestrous	54.8 ± 1.8b
4. Lamb Died	54.6 ± 2.2b
5. Acyclic	51.3 ± 2.2ab
6. Infertile	53.7 ± 1.4b

ANOVA

Source of Variation	d.f.	Mean Square
Breed	1	2395.52***
Class	5	371.524***
Breed x Class	5	48.206
Error	154	26.919
Total	165	

Continued . . .

EFFECT OF BREED AND CLASS ON EWE LIVEWEIGHT MARCH 15, 1978.

Classification	Mean ± S.E. Liveweight (kg)		
	Breed of Ewe		
Class	Romney	BLX	Both Breeds
1. Early Weaned	44.1 ± 2.3a	55.3 ± 2.2a	50.2 ± 1.8
2. Late Weaned	43.8 ± 2.3a	51.1 ± 2.2b	47.6 ± 1.8
3. Oestrous	51.0 ± 2.2b	58.0 ± 2.2a	54.3 ± 1.8
4. Lamb Died	53.6 ± 2.5b	56.7 ± 2.8ab	54.8 ± 2.2
5. Acyclic	46.0 ± 2.5ac	58.9 ± 2.8a	50.8 ± 2.2
6. Infertile	51.1 ± 2.3bc	57.5 ± 1.9a	53.3 ± 1.4
All Classes	48.0 ± 0.9	55.5 ± 0.7	

ANOVA

Source of Variation	d.f.	Mean Square
Breed	1	531.168***
Class	5	310.406***
Breed x Class	5	60.2*
Error	154	25.528
Total	165	

Continued . . .

EFFECT OF BREED AND CLASS ON EWE LIVEWEIGHT APRIL 12, 1978.

Classification	Mean ± S.E. Liveweight (kg) Breed of Ewe		
Class	Romney	BLX	Both Breeds
1. Early Weaned	42.3 ± 2.2a	55.1 ± 2.2a	49.2 ± 1.8
2. Late Weaned	43.0 ± 2.2a	50.1 ± 2.1b	46.8 ± 1.8
3. Oestrous	48.9 ± 2.1b	56.3 ± 2.2a	52.4 ± 1.8
4. Lamb Died	51.5 ± 2.4b	54.8 ± 2.7ab	52.7 ± 2.2
5. Acyclic	43.4 ± 2.4a	56.2 ± 2.7a	48.2 ± 2.2
6. Infertile	50.7 ± 2.3b	56.1 ± 1.8a	52.5 ± 1.4
All Classes	46.5 ± 0.9	54.2 ± 0.7	

ANOVA

Source of Variation	d.f.	Mean Square
Breed	1	2824.55***
Class	5	258.398***
Breed x Class	5	79.914**
Error	154	23.896
Total	165	

Continued . . .

EFFECT OF BREED AND CLASS ON EWE LIVEWEIGHT MAY 10, 1978.

Classification	Mean ± S.E. Liveweight (kg)		
	Breed of Ewe		
Class	Romney	BLX	Both Breeds
1. Early Weaned	42.1 ± 2.1a	53.2 ± 2.1a	48.1 ± 1.7
2. Late Weaned	42.4 ± 2.1a	49.4 ± 2.1b	46.1 ± 1.7
3. Oestrous	48.5 ± 2.0b	55.7 ± 2.1a	51.9 ± 1.7
4. Lamb Died	50.4 ± 2.3b	54.0 ± 2.6ab	51.7 ± 2.1
5. Acyclic	43.4 ± 2.3a	56.0 ± 2.6a	48.1 ± 2.1
6. Infertile	49.5 ± 2.2b	56.7 ± 1.8a	51.9 ± 1.4
All Classes	45.9 ± 0.9	53.4 ± 0.6	

ANOVA

Source of Variation	d.f.	Mean Square
Breed	1	2684.84***
Class	5	264.6***
Breed x Class	5	49.94*
Error	154	21.982
Total	165	

Continued . . .

EFFECT OF BREED AND CLASS ON EWE LIVEWEIGHT JULY 19, NOVEMBER 22, 1978.

Classification	Mean ± S.E. Liveweight (kg)	
Breed of Ewe	July 19	November 22
Romney	45.9 ± 0.9	57.1 ± 1.1
BLX	53.4 ± 0.6	63.5 ± 0.8
Class		
1. Early Weaned	53.1 ± 1.9a	57.6 ± 2.0a
2. Late Weaned	51.2 ± 1.9a	58.5 ± 2.0a
3. Oestrous	56.4 ± 1.8b	62.2 ± 2.0b
4. Lamb Died	57.2 ± 2.3b	60.2 ± 2.4ab
5. Acyclic	52.3 ± 2.3a	58.9 ± 2.4ab
6. Infertile	57.1 ± 1.5b	63.5 ± 1.6bc

ANOVA

Source of Variation	d.f.	Mean Square July 19	Mean Square November 22
Breed	1	2745.76***	1969.39***
Class	5	261.292***	204.76***
Breed x Class	5	48.934	24.28
Error	154	28.790	41.965
Total	165		

APPENDIX IIIA: EFFECT OF BREED, BIRTH RANK AND FLOCK ON EWE LIVEWEIGHT GAIN.

Classification	Period of Gain			
	Mean ± S.E. Liveweight Gain (kg)			
	April 29 - September 16	September 16- November 30	November 30- February 1	February 1- May 10
Breed of Ewe	1	2	3	4
Romney	4.9 ± 0.6	8.3 ± 1.0	3.2 ± 0.4	-4.2 ± 0.4
BLX	7.5 ± 0.5	5.9 ± 0.7	4.2 ± 0.3	-3.2 ± 0.3
Birth Rank				
Single	5.3 ± 0.6	7.9 ± 1.0	3.6 ± 0.4	-3.9 ± 0.4
Twin	7.2 ± 0.5	6.1 ± 0.7	3.8 ± 0.3	-3.5 ± 0.3
Flock				
Joined	7.2 ± 0.7	5.5 ± 1.0	3.4 ± 0.4	-3.5 ± 0.4
Unjoined	2.9 ± 0.6	12.5 ± 0.8	4.6 ± 0.4	-4.5 ± 0.4

Continued . . .

EFFECT OF BREED, BIRTH RANK AND FLOCK ON EWE LIVEWEIGHT GAIN.

Classification	Period of Gain		
	Mean ± S.E. Liveweight Gain (kg)		
	May 10 - July 19	July 19 - November 22	April 29 - November 23
Breed of Ewe	5	6	7
Romney	4.9 ± 0.4	6.2 ± 1.0	23.4 ± 1.0
BLX	4.9 ± 0.3	5.1 ± 0.7	24.5 ± 0.7
Birth Rank			
Single	4.6 ± 0.4	6.2 ± 1.0	23.5 ± 1.0
Twin	5.3 ± 0.3	5.0 ± 0.7	23.9 ± 0.8
Flock			
Joined	5.0 ± 0.4	5.7 ± 1.0	23.2 ± 1.1
Unjoined	4.5 ± 0.4	5.7 ± 1.1	25.8 ± 1.0

Continued . . .

EFFECT OF BREED, BIRTH RANK AND FLOCK OF EWE LIVEWEIGHT GAIN.

Classification	Period of Gain			
	Mean ± S.E. Liveweight Gain (kg)			
	April 29 - May 27	November 30- December 21	December 21- January 11	March 15- April 12
Breed of Ewe				
Romney	3.7 ± 0.3	1.4 ± 0.3	1.1 ± 0.3	-1.6 ± 0.4
BLX	3.3 ± 0.2	1.6 ± 0.2	1.4 ± 0.2	-1.2 ± 0.3
Birth Rank				
Single	3.2 ± 0.3	1.6 ± 0.3	1.3 ± 0.3	-1.7 ± 0.4
Twin	3.9 ± 0.2	1.5 ± 0.2	1.2 ± 0.2	-1.1 ± 0.3
Flock				
Joined	4.0 ± 0.3	1.1 ± 0.3	1.1 ± 0.3	-1.2 ± 0.4
Unjoined	2.1 ± 0.3	2.8 ± 0.3	1.7 ± 0.3	-1.9 ± 0.4

APPENDIX IIIB: ANOVA OF BREED, BIRTH RANK AND FLOCK ON EWE LIVEWEIGHT GAIN

Source of Variation	d.f.	Period of Gain						
		Mean Square						
		(1)	(2)	(3)	(4)	(5)	(6)	(7)
Breed	1	301.05***	237.74**	32.53*	38.84*	0.25	57.26	46.25
Birth Rank	1	68.35*	36.47	6.76	2.37	0.40	64.40	5.15
Flock	1	509.99***	1475.80***	52.67**	27.10*	4.49	1.71	209.12*
Breed x Birth Rank	1	13.36	15.56	0.42	1.57	1.37	15.24	3.38
Breed x Flock	1	25.97	144.84*	2.25	6.33	3.17	35.97	13.95
Birth Rank x Flock	1	1.18	1.02	1.20	4.34	0.19	17.78	2.44
Breed x Birth Rank x Flock	1	10.90	1.01	0.13	19.63†	0.14	23.23	7.32
Error	158	12.402	28.140	5.813	7.141	5.872	38.319	40.778
Total	165							

Continued . . .

ANOVA OF BREED, BIRTH RANK AND FLOCK ON EWE LIVEWEIGHT GAIN.

Source of Variation	d.f.	Period of Gain: Mean Square			
		April-May	November-December	December-January	March-April
Breed	1	5.39	1.26	2.60	4.27
Birth Rank	1	8.86	0.44	0.30	8.37
Flock	1	99.02***	93.30***	8.27	12.09
Breed x Birth Rank	1	1.82	0.87	0.04	9.18
Breed x Flock	1	12.64†	1.32	0	1.70
Birth Rank x Flock	1	4.53	0.89	8.37	2.85
Breed x Birth Rank x Flock	1	0.17	0.98	0.45	17.00†
Error	158	3.77	3.57	3.41	5.10
Total	165				

APPENDIX IVA: EFFECT OF BREED AND CLASS ON APRIL 29 - SEPTEMBER 16 LIVEWEIGHT GAIN.

Classification	Mean ± S.E. Gain (kg)		
Class	Breed of Ewe		
	Romney	BLX	Both Breeds
1. Pregnant	6.9 ± 1.3a	10.1 ± 1.3a	8.5 ± 0.8
2. Oestrous	2.3 ± 1.4b	3.7 ± 1.4b	3.0 ± 0.9
3. Acyclic	2.9 ± 1.6b	3.1 ± 1.8b	3.0 ± 1.1
4. Infertile	3.7 ± 1.5b	5.7 ± 1.2b	4.4 ± 0.7
All Classes	4.9 ± 0.6	7.5 ± 0.5	

ANOVA

Source of Variation	d.f.	Mean Square
Breed	1	214.63***
Class	3	1052.38***
Breed x Class	3	40.76**
Error	158	9.937
Total	165	

Continued . . .

EFFECT OF BREED AND CLASS ON LIVEWEIGHT GAIN.

Classification	Period of Gain[A]					
	Mean ± S.E. Gain (kg)					
Breed of Ewe	2[A]	3	4	5	6	7
Romney	8.3 ± 1.0	3.2 ± 0.4	-4.2 ± 0.4	4.9 ± 0.4	6.2 ± 1.0	23.4 ± 1.0
BLX	5.9 ± 0.8	4.2 ± 0.3	-3.2 ± 0.3	4.9 ± 0.3	5.1 ± 0.7	24.5 ± 0.7
Class						
Weaned	1.3 ± 0.8a					21.0 ± 1.4a
Early Weaned		3.4 ± 0.6a	-3.2 ± 0.7abc	4.9 ± 0.7	4.6 ± 1.7	
Late Weaned		1.6 ± 0.6c	-2.3 ± 0.7a	5.2 ± 0.7	7.2 ± 1.7	
Lamb Died	7.8 ± 1.1b	5.1 ± 0.7b	-5.4 ± 0.9d	5.5 ± 0.8	3.0 ± 2.0	22.9 ± 1.9ab
Oestrous	12.4 ± 0.9b	4.6 ± 0.6ab	-4.4 ± 0.7bd	4.5 ± 0.6	5.8 ± 1.7	25.9 ± 1.6bc
Acyclic	13.1 ± 1.1b	4.7 ± 0.7ab	-4.9 ± 0.9bd	4.3 ± 0.8	6.6 ± 2.0	26.8 ± 1.9bc
Infertile	12.5 ± 0.7b	4.2 ± 0.5b	-4.0 ± 0.6b	5.2 0.5	6.3 ± 1.3	28.7 ± 1.3c

A See Appendix IIIA.

Continued . . .

EFFECT OF BREED AND CLASS ON LIVEWEIGHT GAIN.

Classification	Period of Gain			
	Mean ± S.E. (kg)			
Breed of Ewe	April 29-May 27	November 30-December 21	December 21-January 11	March 15-April 12
Romney	3.7 ± 0.3	1.4 ± 0.3	1.4 ± 0.2	-1.6 ± 0.4
BLX	3.3 ± 0.2	1.6 ± 0.2	1.1 ± 0.3	-1.2 ± 0.3
Class				
Pregnant	3.8 ± 0.5a	-	-	-
Early Weaned	-	1.3 ± 0.4a	0.6 ± 0.5a	-1.0 ± 0.6ab
Late Weaned	-	-0.5 ± 0.4b	0.8 ± 0.5ab	-0.9 ± 0.6a
Oestrous	2.0 ± 0.5b	2.9 ± 0.4c	1.7 ± 0.5b	-2.0 ± 0.6ab
Lamb Died	-	2.9 ± 0.5c	1.4 ± 0.6ab	-2.0 ± 0.7ab
Acyclic	3.6 ± 0.6ac	1.5 ± 0.5a	1.6 ± 0.6ab	-2.6 ± 0.6b
Infertile	4.9 ± 0.4c	2.0 ± 0.3ac	1.9 ± 0.4b	-0.8 ± 0.5ab

APPENDIX IVB: ANOVA OF BREED AND CLASS ON LIVEWEIGHT GAIN.

Source of Variation	d.f.	Period of Gain					
		Mean Square					
		2[A]	3	4	5	6	7[A]
Breed	1	48.94*	56.29***	22.78	0.34	64.35	139.67*
Class	5	1146.24***	55.84***	32.74***	5.14	55.45	371.66***
Breed x Class	5	19.80†	5.10	4.88	1.45	28.39	27.54
Error	154	10.139	4.375	6.539	5.994	37.700	32.558
Total	165						

A Class d.f. = 4, Breed x Class d.f. = 4, Error d.f. = 156.

Continued . . .

ANOVA OF BREED AND CLASS ON LIVEWEIGHT GAIN.

Source of Variation	d.f.	Period of Gain			
		Mean Square			
		April-May[A]	November-December	December-January	March-April
Breed	1	3.58	6.48	6.06†	2.59
Class	5	48.10***	54.27***	8.45*	12.69*
Breed x Class	5	2.30	1.07	2.73	4.73
Error	154	3.667	2.494	3.251	5.009
Total	165				

A Class d.f. = 3, Breed x Class d.f. = 3, Error d.f. = 158

APPENDIX V: EFFECT OF BREED, SEX AND GROUP ON BIRTH DAY (WEANED LAMBS).

Classification:	Birth Day (January 1 = Day 1)
Breed of Dam	
Romney	284.2 ± 1.8
BLX	277.2 ± 1.3
Group	
Early Weaned	280.4 ± 1.9
Late Weaned	281.3 ± 1.2
Sex	
Male	280.6 ± 2.0
Female	280.7 ± 1.3

ANOVA

Source of Variation	d.f.	Mean Square
Breed	1	955.734***
Sex	1	15.801
Group	1	27.537
Breed x Group	1	24.031
Breed x Sex	1	61.602
Sex x Group	1	39.436
Breed x Sex x Group	1	0.906
Error	69	67.140
Total	76	

APPENDIX VI: GROSS MARGIN FOR STORE SHEEP

Assumptions:

- Romney rams x Romney ewes
- 100% lambs weaned
- Idealized flock age structure
- 1000 ewes
- 5% losses
- 5% culling
- 5-year-old ewes sold as cast-for-age (C.F.A.)
- Own replacements retained
- Cull two-year-olds sold

Gross Revenue per 1000 Ewes

	300 prime wether lambs @ $18.00 net	$5400.00
	200 store wether lambs @ $16.00 net	3200.00
	50 cull ewe lambs @ $15.00 net	750.00
	140 cull two-year-old ewes @ $25.00 net	3500.00
	50 cull ewes @ $12.00 net	600.00
	191 C.F.A. ewes @ $15.00 net	2865.00
Wool:	1000 ewes @ 4.5 kg	
	700 lambs @ 1.0 kg	
	450 ewe lambs @ 3.0 kg	
	6550 kg @ $2.60 net	17030.00
		$33345.00

Direct Costs per 1000 ewes

5 rams @ $140	$ 700.00
Shearing and crutching	2200.00
Animal Health	800.00
	$3700.00

Gross Margin per 1000 ewes	$29645.00

APPENDIX VII: Liveweights and Estimated[A] Dry Matter Intake (DMI) differences between Pregnant/Lactating and Non-pregnant ewe lambs over August - November and Liveweights (LW) and Estimated[A] DMI of the progeny of lactating ewe lambs over October and November.

	Ewe Lambs		Progeny		Both
Month	Initial LW (kg)	DMI (kg)	Initial LW (kg)	DMI (kg)	DMI (kg)
August	38	+11			+11
September	41	+15			+15
October	41	+16	5	+3	+19
November	40	+20	10	+15	+35
All Months		+62		+18	+80

A Derived from data presented in Sheep and Cattle Nutrition. Compiled by Scott *et al.*, 1980.