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A STUDY ON THE BREEDING PERFORMANCE
OF ROMNEY AND BORDER LEICESTER CROSS ROMNEY
EWE HOGGETS AND TWO-YEAR-OLD EWES

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of the requirements for the degree of
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ABSTRACT

The objectives of the investigation were to examine the natural breeding and productivity of ewe hoggets in comparison with non-bred hoggets and then to determine their production as 2-year-old ewes under grazing conditions. Observations were made on the occurrence of oestrus and conception and especially on events associated with parturition, the lactation period and nursing of the offspring, and the females' rebreeding performance.

Four hundred and nineteen ewe hoggets born in either August-September 1979 (210) or 1980 (209) from the same flock were studied. They comprised 178 Romney and 241 Border Leicester first cross Romney (BLX) animals.

The mean liveweights of the Romney and BLX hoggets at the time of joining were 34.9 and 38.5 kg and for the 2-year-old ewes 44.7 and 50.2 kg, respectively. The ewes which lambed at 1 year of age compared to the non-bred animals were about 2 kg lighter, but this difference was gradually reduced over the subsequent year.

The mating periods with entire rams of 28 days and 42 days resulted in 83% of the hoggets and 99% of the ewes being marked respectively. Hoggets which weaned a lamb came into oestrus in the following year almost at the same time as those not previously pregnant. Marked variation in the onset of oestrus in the ewes between years was probably due to the presence of "teaser" rams before the joining period.

Conception rate for all services per ewe joined, lambing percentage, and weaning percentages were higher for BLX than for Romney at both ages, but the differences between primi- and multi-parturient ewes were not significant.

A number of behavioural traits of the ewe were recorded before and after parturition as were observations on the lambs until successful sucking occurred. A general pattern of behaviour of the ewe close to lambing was established, but the occurrence of different traits did not allow accurate prediction of the time for parturition. Behaviour traits at both ages were not affected by breed, lamb rank or year of study, and among the 2-year-olds, whether they were primi- or multi-parturient.

The mean lengths of labour were 42 min and 69 min for hoggets and 2-year-old ewes, respectively. Differences in labour between breeds were not significant at both ages and the difference between primi- and multi-parturient ewes was not significant.

During the post-lambing period similar patterns of maternal behaviour were shown by hoggets and ewes. The majority of animals were on their feet in about 5 min after lambing. Exceptions to this were mainly associated with dystocia.

The mean interval from delivery of the lamb until it stood on its feet was about 16 min for both the progeny of hoggets and 2-year-old ewes. Lambs from hoggets took longer to start sucking the udder after getting to their feet than did the lambs from ewes (35 v 18 min). In general hoggets had a low incidence of lambing difficulty and were good mothers; losses among lambs due to poor maternal behaviour were negligible for both ages of dam.

The birth weights of the lambs from the Romney hoggets were slightly heavier than those of BLX hoggets (3.80 v 3.44 kg), but this was associated with the unequal distribution of twins, there being fewer from Romneys. Among the 2-year-old ewes the breed did not cause a significant difference in birth weights (4.26 v 4.53 kg) nor was the birth weight influenced by the ewe having previously lambed as a hogget.

The daily growth rates of the offspring of BLX were superior to those of Romneys (201 g v 183 g and 271 g v 249 g) for both hoggets and 2-year-old ewes respectively. The growth rates of lambs from 2-year-old ewes were generally higher than those for the progeny of hoggets and single lambs reared by hoggets were comparable at least with those of twins reared by animals one year older. Multi-parturient and primi-parturient ewes weaned lambs almost similar in weight.

The total lamb mortality between birth and weaning was 20% and 16% for hoggets and 2-year-old ewes respectively.

Milk production of 52 hoggets and 61 ewes, each rearing a single lamb, was recorded at 3-weekly intervals using an oxytocin injection - hand-milking method. Among both the hoggets and ewes the BLX produced more milk than did the Romneys. Lactation curves were of similar shape

for Romney and BLX groups at both ages. Milk production peaked approximately 3 weeks post partum and then decreased until weaning at the 9th and 12th weeks for hoggets and ewes, respectively.

The percentage of milk protein changed significantly between different stages of lactation at both ages. The change in milk fat percentage was not significant for the hoggets, but more variation was apparent in the milk of the ewes.

Sex of the lamb did not influence the milk yield, the milk protein or the milk fat percentages in both ages of dam. The primi- and multi-parturient ewes had similar milk yields, protein and fat percentages, respectively.

Milk yield and daily growth rate were significantly correlated at 4-6 weeks of lactation in hoggets but not in the ewes. The protein and fat percentages were not significantly related to lamb growth rates.

The wool production for the BLX animals was higher than that for the Romneys at September shearing (yearling) and at the following February and December shearings. Yearling fleece weights did not vary significantly between groups of hoggets classified for their reproductive history (Acyclic, Mated by teaser rams, Lambled, Mated but not lambled). Fleece weights in February for those which had lambled as a hogget were about 0.16 kg lighter than the other groups. There was no carry-over effect of hogget lambing on fleece weight at the following December shear.

Under the conditions of the trial it was evident that good levels of performance were achieved in the hoggets and in the following year. This has required sound management and good feeding levels so as to regain liveweight that is lost after lambing and especially during lactation. Reduction in the length of the lactation period as well as provision of sufficient feed prior to next mating appear important factors if successful breeding of hoggets is to be part of the farming system. Nevertheless breeding as a hogget will usually result in a transient slight decrease in fleece weight.

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CHAPTER ONE

INTRODUCTION

INTRODUCTION

Methods to increase the efficiency of sheep production are sought if the New Zealand sheep industry is to remain competitive. An increase in the number of lambs born during the breeding ewe's productive lifetime is one "pathway" that could result in increased efficiency being achieved. This increase could arise from more offspring per pregnancy or the animal breeding over a longer lifespan.

In most New Zealand sheep flocks, ewes are normally bred to lamb at two years of age, but many animals do have the capacity to breed at earlier ages. In some instances ewe hoggets are mated on some farms in New Zealand, but this practice is not widespread. Overseas, early breeding of ewe hoggets is frequently the normal practice and because of the good conception rates and lambing percentages achieved it is relevant to study this in relation to increased efficiency of production in New Zealand.

Breeding from ewe hoggets could have value from several viewpoints in addition to increased lifetime production. Other reasons which may be advanced include: earlier recognition of female and male fertility, the potential for earlier ram selection, for progeny testing and reduction in the generation interval and increased rate of genetic improvement.

Commercial farmers have advanced a number of reasons why early breeding of hoggets does not suit their particular breeding flock. One reason often put forward is that the rebreeding performance of the animals at two years of age is depressed by the carry-over effect of hogget pregnancy and lactation. This observation may be correct but its effect might be alleviated by changes in the management and nutritional system given to the animals. It is clear, however, that further work is required to establish the significance of various factors which determine the productivity of the animals as hoggets and at later ages.

The conclusion reached from many studies on the breeding of ewe hoggets is that at this age the animals reproduce at a lower rate than at the two-year stage and older ages. This is due to lower body weights and in general the state of immaturity of the animals. Thus the breeding season starts later, ovulation rate is lower and conception and fertility are less than

might be hoped for. As well, a higher incidence of neo-natal mortality among the lambs occurs. All these facts require a better understanding than is presently the case if management methods are to be devised to increase the level of performance. While investigations into the breeding performance of the ewe hogget are important, it should not be overlooked that the hogget must also rear the lamb until weaning, and therefore its lactational performance also needs to be assessed. Research needs to be devoted to characterizing critical aspects of the reproduction and lactation processes and should look for management procedures that will increase output.

The work now to be presented in this thesis has concentrated on the late stage of pregnancy, parturition and the lactation period until weaning in the hogget, and on its rebreeding performance.

CHAPTER TWO

REVIEW OF LITERATURE

A. REPRODUCTIVE ACTIVITY IN EWE HOGGETS

The proportion of ewe hoggets which experience oestrus in their first "breeding" season, the time and onset of first oestrus and the duration of sexual activity all depend to a very great extent on the animals' genetic background (Quirke, 1981). Studies in New Zealand with several breeds or crosses have shown quite variable results for the incidence of oestrus (Ch'ang and Raeside [1957], 72%; Hight et al. [1973], 50-64%; Allison and Kelly [1978], 47%; Meyer and French [1979], 25%, Baker et al. [1981], 75%). Much of the variation in the incidence of oestrus may be due to genetic differences but between-year variation can be marked. Thus in Romney ewe hoggets 82%, 48% and 41% were in oestrus during consecutive years (Moore et al., 1983). The two "genotypes", Romney and Border Leicester first cross Romney (BLX), considered in the present study have shown a high incidence of puberty i.e. Romney 88% and BLX 92% (McMillan and McDonald, 1983), but lower proportions reached puberty under other conditions (eg. 50-64%, Hight et al., 1973). It appears that cross-bred ewe hoggets tend to have better reproductive performances than pure breeds and this may be due to earlier sexual development. More crossbred ewe hoggets come into oestrus and also experience more oestrous periods than straight-bred animals (Cleverdon, 1980).

Ovulation without oestrus (silent heat) occurs frequently in ewe hoggets as it does in mature ewes. Cleverdon and Hart (1981) found that 56% of ewe hoggets had experienced one and 26% experienced two or more silent heats respectively prior to first oestrus. Oestrus without ovulation was also reported at the end of the first breeding season (Cleverdon, 1980).

Most oestrus periods are accompanied by a single ovulation, but twin ovulations are not uncommon at least in the breeds so far studied (Hight et al., 1973; Allison et al., 1978; Meyer and French, 1979; Cleverdon, 1980; McMillan, 1981). In high fecundity breeds, such as Finnish Landrace, Booroola Merino and their crosses, the incidence of ovulations in ewe hoggets is higher than in other breeds (Meyer and French, 1979). Many studies suggest that the incidence of oestrus and of multiple ovulation is associated with variation in liveweight, although considerable overlap exists in weight between ewes of "oestrus" and

"number of ovulations" classes (Hight et al., 1973; Hight and Jury, 1976; McCall and Hight, 1981; Moore and Smeaton, 1980; Meyer, 1981). The various factors (level of nutrition, breed, type of birth and stage within season) known to influence ovulation rate in the adult ewe, probably also contributes to variation in ovulation rate in ewe hoggets, but the magnitudes of the responses appear to be lower (Hight et al., 1973; Cleverdon and Hart, 1981; McMillan, 1981). Cleverdon and Hart (1981) in a study comparing several breeds and crosses in New Zealand, reported that the effect of plane of nutrition was less marked than the effect of breed on ovulation rate. Not all studies have reported an influence of level of nutrition on ovulation rate in ewe hoggets (Keane, 1974, 1975b). Differences between years in ovulation rate have been noted by Keane (1974) and Hamra and Bryant (1979). The fertility of ewe hoggets that are bred seems to be more variable than that found in mature ewes and is often about 20% lower. Several studies have attempted to elucidate the stages when reproductive loss occurs in ewe hoggets (Quirke, 1977; Edey et al., 1978). Quirke (1981) has reviewed the evidence on the source of prenatal mortality.

B. PUBERTY AND FACTORS WHICH AFFECT IT

Asdell (1946) has defined puberty as "the time at which reproduction first becomes possible and is characterized by the release of germ cells, whereas sexual maturity is not reached until the animal expresses its full reproductive power." Ewe hoggets usually reach puberty in their first year but complete reproductive capacity does not occur until 4-5 years when maximum lambing percentage is noted. The onset of puberty is considered to be due to the interaction of hormones with target tissues and endocrine glands (Quirke, 1981).

1. Breed.

Dyrmundsson (1981) has summarized many reports on the variation in the incidence and onset of puberty for a range of breeds and crosses and the environmental factors which interact.

Great variation exists between breeds and strains within breeds in the incidence of oestrus (Dyrmundsson, 1981; McMillan and McDonald, 1983). Bruce (1982) has shown that a significant breed difference occurred only in the incidence of first oestrus.

2. Age and Bodyweight

Several studies in New Zealand show that animals which reach puberty in the first autumn or winter tend to be heavier than those which fail to do so (Ch'ang and Raeside, 1957; Hight et al., 1973; Allison et al., 1975; Allison and Kelly, 1978; Moore et al., 1978; Meyer and French, 1979; Baker et al., 1981; McMillan and McDonald, 1983). Similar results have been found in some overseas studies (Quirke, 1978; Al-Wahab and Khudayeer, 1981), but in some others the differences were not statistically significant (Keane, 1974, 1975a; Baker et al., 1978; Quirke, 1979). In general, it appears that faster growth rate during rearing will normally favour an earlier onset of oestrus at a lower age and heavier bodyweight; lambs growing at slower rates, and this usually includes twin lambs, will normally exhibit oestrus later in the season at higher mean ages but lower mean bodyweights.

3. Nutrition

Any discussion of the influence of nutrition on reproductive function must consider the interaction between the basic physiological regulators of reproduction, the genetic variation and environmental factors. Many studies have suggested that ewe hoggets on a high plane of nutrition are younger at their first oestrus than those reared on a lower plane of nutrition (Keane, 1974; Moore et al., 1978; Hamra and Bryant, 1979; Cleverdon, 1980; Moore and Smeaton, 1980) and are also heavier (Keane, 1974; Al-Wahab and Bryant, 1978; Moore et al., 1978; Cleverdon, 1980; Moore and Smeaton, 1980; Hamra and Bryant, 1982). Different nutritional treatments had a greater effect on the components of oestrous activity than on ovulation rate, and a greater proportion of ewe hoggets on a high plane of nutrition attained puberty during their first breeding season than those on a low plane (Cleverdon, 1980). A close relationship between growth rate and the proportion of hoggets reaching puberty has been reported by Downing and Lees (1977). At high growth rates, the plane of nutrition made little difference, but at low growth rates, differences in nutrition were more important, particularly for hoggets born late in the year. Moreover, Moore and Smeaton (1980) reported that the time of birth and level of nutrition were the two most important factors influencing oestrus in ewe hoggets, and the time of birth became most important when low nutrition prevailed.

Doney (1979) indicated that hoggets which failed to reach the characteristic weight for the breed by the middle of the normal breeding season, whether due to lateness of birth or to slow growth rate, were unlikely to come into oestrus in their first year. Southam et al. (1971) noted that the incidence of puberty was changed from 12% to 88%, simply by providing additional feed following early weaning. Hoggets with slower growth up to 12 months of age may show a lower adult reproductive rate than well-grown hoggets long after the growth differential had been compensated (Gunn, 1977).

4. Photoperiod

Little attention has been given to the photoperiodic regulation of breeding activity in ewe hoggets. Smith (1982) stated that day-length is an important factor affecting the seasonal pattern of oestrous activity. The onset of oestrous activity in the majority of non-tropical breeds usually occurs during the period of decreasing daylight hours (Autumn-Winter). Ducker et al. (1973) found that various artificial light treatments only modified the occurrence of oestrus in ewe hoggets, while neither Radford (1961) nor Smith (1967) could show any convincing effect of extended light patterns. Cedillo et al. (1977) suggested that early well-grown hoggets reached the threshold weight before the changing of daylight length permitted oestrous activity. Ewe hoggets which failed to reach the characteristic weight for the breed by the middle of the normal breeding season were unlikely to show oestrus in their first year. In considering this factor it has to be appreciated that late-born hoggets must be of sufficient size and age to respond to the photoperiodic influence. Thus the interval to first oestrus or puberty becomes considerably longer in such animals.

5. Presence of the Ram

Information on the influence of the ram as a factor causing variation in the time of puberty is limited. In adult sheep synchronisation of the oestrous cycle can be obtained using the "ram effect" (Underwood et al., 1944) and this has been used commercially (Corke, 1980). Dyrmondsson and Lees (1972) reported a high degree of synchronisation of oestrus in ewe hoggets when a sudden introduction of rams was used at the transition from non-breeding to breeding activity.

Different studies have indicated that most breeds of ewes can be stimulated by the ram (Merino - Schinckel, 1954; Romney - Edgar and Bilkey, 1963; Corriedale - Lyle and Hunter, 1967; Prealpes, Ile-de-France and Berrichon - Cognie et al., 1980). It was found that teasing for 24 h increased the percentage of ewes exhibiting oestrus 17-24 days later and 48 h teasing was required to give a response similar to teasing for 17 days (Knight, 1980). Romney ewes can be stimulated by rams, 2-4 weeks before the onset of the breeding season (Edgar and Bilkey, 1963), while Merino ewes will respond to teasing at almost any time during anoestrus (Lisham, 1969). Ewes and rams run together continuously, have a level of anoestrus similar to isolated ewes (Knight, 1983). However, isolation for 21 days has been found to be adequate for Ile-de-France ewes (Oldham, 1980).

Watson and Radford (1960) provided the first evidence that the stimulation of ewes was mediated by ram pheromones. The wool and wax from rams contain pheromones which, when applied to anoestrous ewes, will stimulate them to ovulate (Knight and Lynch, 1980a, b; Knight et al., 1983).

The breed of rams is also a factor, as Tervit et al. (1977) observed that Dorset rams stimulated ewes more effectively than Merino rams and these more than Romney rams. Knight et al. (1980) has confirmed the superiority of Dorset rams over Romneys.

The ability of rams to stimulate ewes may vary between seasons (Knight, 1983).

6. Hormone Induction of Breeding

Hormonal treatment of ewe hoggets can induce early ovulation and advance the onset of puberty (Mansour, 1959). Such treatments might be explored to enable super-ovulation of prepuberal ewe hoggets for egg transplantation purposes. The animals might also be treated at 7-10 months of age in order to advance the breeding season to synchronise cycles in those which attained puberty, and to induce oestrus in ewe hoggets which might not otherwise be mated during their first year. Different techniques used to lower the age at puberty involve inducing a synchronised oestrus with progestagens and PMSG (Dyrmundsson, 1981), and in general ewe hoggets respond to such hormonal treatments when the

animals are close to the onset of natural breeding activity at the time of treatment. Hormonal treatment of ewe hoggets with progestagens alone has been investigated in New Zealand (Ch'ang et al., 1968) but the treated animals have not been mated and so no data are available on lambing performance after induction. Ewe hoggets induced with progestagens and PMSG have less cycling activity compared with animals receiving progestagens alone, but this observation needs confirmation (McMillan, unpublished results). The duration of oestrus in ewe hoggets and in adult ewes is similar following progestagen-PMSG treatment (Quirke et al., 1981). Smith (1982) stated that manipulation of the normal endocrine pattern by the use of oestrus synchronisation treatments has often been shown to cause a reduction in fertility, and higher prenatal mortality in ewe hoggets than in adult ewes (Quirke, 1981). Because of the low value of sheep and their products in New Zealand compared to other countries, hormonal treatment in ewe hoggets is unlikely to be widely used for inducing breeding at early age.

C. PARTURITION AND ASSOCIATED BEHAVIOUR

Little detailed information is available on the behaviour of ewe hoggets and two-year-old ewes at parturition and their lamb(s) in the early suckling period. Research on some specific aspects of maternal behaviour, mainly for mature ewes has been conducted, but such studies need to be related to the flock grazing conditions that prevail in New Zealand.

Hersher et al. (1963) defined the term "maternal behaviour" in the sheep as "a rapid and early development of strongly individual-specific maternal bonds and care limited to the mother's own offspring with the rejection of other young who may approach".

"Maternal behaviour" has also been described by Holmes (1971) as "that behaviour specifically related to the bearing and delivery of the lamb, the provision of maternal care and the relationship of the dam to her offspring after it has ceased to be dependent on her".

The first detailed and objective studies of Romney ewes at lambing were reported by Wallace (1949). The parturient behaviour of other breeds has been described by Sharafeldin and Kandeel (1971); Arnold and Morgan (1975); Holmes (1975); Owens et al. (1980) and

Stevens et al. (1981).

The age of the ewe influences behaviour and mature ewes seem to have well-developed behaviour patterns (Alexander, 1960; Sharafeldin and Kandel, 1971). The work of Lewis (1959) indicated that mothering ability of ewe hoggets is at least as good as that of maiden 2-year-old ewes.

1. Preparation for lambing.

(a) Pre-partum behaviour:

Near the onset of lambing the majority of ewes display a range of activities including increased restlessness, walking, seeking other animals, isolating themselves from the flock, vocalizing, pawing at the ground, and showing interest in foetal fluids or in newborn lambs from other ewes (Wallace, 1949; Hersher et al., 1963; Sharafeldin et al., 1971; Arnold and Morgan, 1975; Holmes, 1975; Owens et al., 1980; Kilgour, 1982). Alexander (1960) reported that no sign of maternal behaviour was displayed until the ewe was on the point of labour. However, Fraser (1967) reported that only 20% of his flock showed no premonitory signs of parturition. With the New Zealand Romney, Wallace (1949) noted that 15% of ewes were "uneasy" more than 3 h before birth and 40% first showed "uneasiness" in the last hour prior to birth. Other activities have also been noted. Thus, in Egyptian Barki sheep, the ewes will often look backwards, tap gently on their bellies with one of their fore-hooves and shake their tails nervously (Sharafeldin et al., 1971).

(b) Maternal interest:

The onset of maternal interest in the ewe is closely associated with parturition; and attraction for newborn lambs by barren ewes is uncommon (Scott, 1945). It is frequently found that many pregnant ewes will show interest in the lamb(s) of other ewe(s) prior to the birth of their own, and that this can result in confusion of ownership or abandonment and eventually lamb death (Alexander, 1960; Hersher et al., 1963; Shelley, 1970; Welch and Kilgour, 1970, 1972; Owens et al., 1980; and Kilgour, 1982). Welch and Kilgour (1970) have noted the incidence and prevalence of lamb-stealing in small flat paddocks where 10 or more ewes were lambing at one time. They observed a temporary overnight

adoption by the ewe for a lamb which suckled it before being reclaimed by its own mother. In one case the thieving ewe lambled five days later. Most ewes appear to lose interest in an adopted lamb after parturition and Morgan (1970) found that although the real mother might be forced away, it often regained the lamb at the time of the stealer's own parturition. Maternal interest was observed only within 8 h of lambing and on most occasions within 2 h (Arnold and Morgan, 1975). Pedigree records of identity could have about a 10% error as a result of lamb stealing (Welch and Kilgour, 1970).

(c) Isolation:

Pre-parturient ewes often separate themselves from the rest of the flock (Welch and Kilgour, 1970; Sharafeldin et al., 1971; Arnold and Morgan, 1975; Stevens et al., 1981; Kilgour, 1982). Romney ewes with newborn lambs frequently are observed during daylight hours, well apart from the main flock (Welch and Kilgour, 1970). Stevens et al., (1981) after continuous observations of Merino sheep, noted that less than 10% of ewes appear to deliberately isolate themselves for birth, and the majority deliver their lambs where the flock happens to be. This is in agreement with observations of Arthur (1961). However, several observers have recorded the separation as more in the nature of a failure to keep up with the grazing movements of the flock particularly when the onset of parturition is sudden (McBride et al., 1967; Fraser, 1967; Welch and Kilgour, 1970; Shillito and Hoyland, 1971).

Management practices for the flock can affect the behaviour of the pregnant ewe close to lambing. Thus routine separation of recently-lambled sheep from pregnant ewes could disturb the ewe which had settled on its lambing site and was in the process of lambing (Jefferies, 1969). The benefits of drift-lambing of ewes might therefore be reduced if pre-partum sheep are disturbed near to lambing.

(d) Selection of lambing site:

Ewes of various breeds seek out a place for lambing (Welch and Kilgour, 1970; Hulet et al., 1975; Stevens et al., 1981). Kilgour (1982) noted that ewes often have "favoured" lambing sites in a paddock; these areas are irrespective of the point of entry into the

paddock and are stable from year to year. The reasons why ewes select the same favoured areas for lambing in each paddock are unclear. Hilly ridges and areas near fence lines are frequently selected, while many open areas of the paddock are avoided (Kilgour, 1982).

Winfield et al. (1969) reported that ewes quickly left the site of parturition with their lambs in fine weather, but those lambing about dawn remained there longer. Many ewes will remain at the birth site for up to 8 h if parturition was difficult (Kilgour, 1972). Alexander et al. (1983) has compared Romneys at Waihora (New Zealand) and Merinos at Armidale (Australia), noting the time that the ewes spent with their first twins on the lambing site. Romneys lambing twins as hoggets or as two-tooth ewes averaged 10 h on the lambing site before spontaneous movement, while mature Romneys with previous lambing experience moved after 6-7 h. Merino ewes in Australia averaged 2-3 h at the site and then moved. Kilgour (1982) has observed ewes lambing in 3 consecutive years and noted that the period spent on the lambing site after birth was quite variable (range 2 to 72 h). The lambing site is the place where recognition between ewes and lambs takes place, and it is also a location point to which ewes and lambs become oriented.

Knowledge of the lambing site can provide the observant shepherd with useful information. Thus lambs born dead will be at the lambing site and if the placental membranes have not been eaten, they can be examined to determine the number of lambs born to the ewe.

2. Parturition.

The uterus is remarkably quiescent during pregnancy, and it is only a few hours before birth that it starts to show an increase in the regular and powerful muscular activity necessary for expulsion of the foetus. At the same time characteristic hormonal changes are taking place (McSporran, 1973).

(a) Physiology of lambing:

The physical signs of impending parturition involve the discharge of fluids and protrusion of the amniotic sac. Arnold and Morgan (1975) noted that about 70% of ewes display these signs and they start at any time from 14 h to 11 min prior to birth. The average time

from release of the foetal fluids to birth is 68 min (range 10 min to 3 h; Kilgour, 1982). Dark red and sometimes clear, fluid-filled sacs protrude from the vagina at various times before foetal delivery, usually from about 10 min before first straining and during later straining, and between foetal deliveries (Holmes, 1975). Shortly before lambing there is a rapid engorgement of the udder and belly and swelling of the vulva (Hersher et al., 1963; Shillito and Hoyland, 1971; Hindson and Ward, 1973). Straining may be divided into occasional and regular types (Holmes, 1975), and may occur up to one hour before foetal delivery. Regular and intense straining starts about 20 min before delivery of the first-born in all litters (Owens et al., 1980). The parturient uterine contractions last about 30 seconds and recur at approximately one-minute intervals. Straining efforts are continuous and increase during the passage of the foetal head and shoulders (Sharafeldin et al., 1971; Holmes, 1975; Hulet et al., 1975). This effort stops after delivery of the trunk (Fraser, 1968). The delivery of the first lamb may dilate and relax the cervix and birth canal, thus facilitating the exit of the second and subsequent lambs (Arnold and Morgan, 1975; Holmes, 1975; Owens et al., 1980). Most ewes are in labour for less than one hour and very few more than two hours.

(b) Birth process:

Parturition is normally divided into three stages (Smith, 1982), and the characteristics of these are as follows:

Stage 1 - Contractions of the uterine muscle occur over a period of 1-24 h. The cervix dilates, and the water bag appears.

Stage 2 - The cervix opens completely, associated with contractions of the abdominal diaphragmatic muscles and passage of the foetus through the cervix, vagina and vulva. This expulsive stage lasts 30 min to 2 h.

Stage 3 - Expulsion of the placenta will occur about 30 min after delivery, but up to 8 h may elapse.

Involution of the uterus occurs gradually and usually within about 30 days of parturition.

(c) Time between lamb deliveries:

The interval between the birth of the first and second lambs is usually 11-20 min, but it can be up to 45 min and can sometimes be much longer, eg. 172 min (Arnold and Morgan, 1975; Holmes, 1975; Hulet et al., 1975; Owens et al., 1980; Kilgour, 1982). Holmes (1975) reported that there was no apparent difference between breeds or comparable classes of lambs, in the interval between natural deliveries of lambs. The speed of lambing will be influenced by factors such as dystocia, and selection of easy-care sheep is thought to favour more rapid lambing.

(d) Distribution of time of lambing

Wallace (1949) in his study of New Zealand Romney flock ewes found that lambing was spread throughout the 24-hour period with a small peak between midnight and 4 a.m. Other studies (eg. Arnold and Morgan, 1975, and Owens et al., 1980) show that there is no consistent time when peaks of lambing occur and it probably happens randomly during the 24 hours. Hulet et al. (1975) noted that the effects of various factors such as weather, artificial illumination, handling or changes in human activity nearby, are unknown. Some of these factors may act to synchronise parturition.

3. Events after lambing

(a) Grooming:

The attraction of the ewe to the lamb involves the foetal fluids, as there is considerable interest in the ewe's own freshly-spilled fluids, or in the fluids from other ewes. The mother will groom the wet lamb for an hour or so after birth (Alexander, 1980). This initial attraction to the birth fluids is replaced by a specific attraction to the lamb (Hulet et al., 1975). However, several studies have shown that most ewes followed a common pattern in grooming. Usually this started at the head or neck and continued to the belly and flanks, then licking and/or eating of the umbilical cord and further licking of the lamb's body toward the tail (Sharafeldin and Kandeel, 1971; Holmes, 1975; Hulet et al., 1975; Owens et al., 1980). Sharafeldin and Kandeel (1971) noticed that licking of

the mouth and nose of the young helped them to breathe easily, and also that the lamb was physically stimulated when the ewe licked the perineal area. The least active lamb in a litter usually received least grooming attention from the ewe and there was no obvious trend in grooming by the ewe for the first- or subsequently-born lambs (Owens et al., 1980). Grooming was usually interrupted when the ewe commenced straining to deliver the next litter member (McBride et al., 1967; Owens et al., 1980). The first-born lamb often gets more attention than a late-born member, suggesting that maternal drive decreases with increase in litter size (Holmes, 1975). However, by the time the lamb is several hours old the attraction by the ewe has become "imprinted" for an individual young (Alexander, 1980). This early specificity is based on olfaction, since intense sniffing of the young occurs. Endocrine changes at parturition probably play a key role in altering the sensitivity of the sense of smell by the ewe (Klopfer, 1971).

(b) First suckings:

There is a critical period during which the new-born learns to suck from its mother and the ewe, if she is inexperienced, learns to suckle the lamb (Alexander, 1980). Suckling usually occurs within the first hour or two of life (Wallace, 1949; Arnold and Morgan, 1975; Alexander, 1980; Owens et al., 1980). Successful sucking can be reduced by circumstances which cause delay, such as if the ewe is lying on the ground after birth, or is absent attending to the lamb's twin - or triplet - mate, or if the weather is cold (Alexander and Williams, 1966). It is not clear what attracts the lamb to the teats, but obviously they are found by trial and error (Smith, 1965; Alexander, 1980). Maiden ewes tend to keep the lamb positioned to their front, but after a period they allow sucking attempts from the udder (Owens et al., 1980). Most ewes help the new-born lamb in its attempts to suck, by standing still and allowing the lamb to progress along their bodies to the udder (Alexander, 1960; Sharafeldin and Kandeel, 1971; Owens et al., 1980). In some cases ewes tend to lift the hind legs slightly or crouch to allow easy access to the udder (Sharafeldin and Kandeel, 1971; Hulet et al., 1975; Owens et al., 1980). The position of the lamb when sucking allows the ewe to lick and sniff the lamb's perineal area, which appears to play a part in the establishment of the maternal bond (Hulet et al., 1975; Owens et al., 1980). Single lambs take less time to suck successfully than lambs born in litters, and there is a tendency for the

second- and third-born of twins and triplets to be quicker to suck than their first-born litter mates (Owens et al., 1980). With twin lambs there is a longer mean interval from standing to drinking than for singles. Results of Holmes (1975) and Owens et al. (1980) are equivocal as to whether the ewe will discriminate between litter members to allow one particular lamb to suck more than others. The increase in attention may arise because of differences in activity between litter mates at any particular time. The mean intervals from birth to standing and from standing to drinking are not associated with breed, age of the ewe, pre-lambing nutrition nor with climatic effects such as rainfall, wind speed or air temperature (Arnold and Morgan, 1975).

(c) Ewe-lamb bond:

Although true maternal behaviour starts with the birth of the lamb, preparation for it occurs during the later stages of pregnancy (Herbert, 1972). The essential feature of maternal-offspring behaviour is the rapid development by the ewe of a bond with her lamb, to the exclusion of other lambs. The bond between the lamb and mother develops more slowly (Alexander, 1980). Under natural conditions, ewes tend to move out of the group and lamb in relative isolation, only bringing their lambs back to the main flock several days after birth (Grubb and Jewell, 1966; Grubb, 1974). Time is needed for good bonding to be accomplished when the initial interaction between ewes and their lambs takes place (Kilgour, 1982). It is noticed that the attraction of ewes to the birth fluids is replaced by a more specific attraction to the lamb (Hulet et al., 1975; Alexander, 1980). If lambs are substituted up to this time, then the ewe will take the "alien" as her own offspring (Alexander, 1980). By the time the lamb is several hours old the attraction has become specific and the ewe becomes "imprinted" with the individual young (Alexander, 1980). During the critical hours after birth, the new-born may attach itself to, and follow, a substitute maternal "figure" even if the "new mother" supplies no food (Kilgour, 1972). Sheep are a "follower" type of species, and the lamb keeps close to the dam from the time of birth, suckles frequently and tends to follow wherever the ewe moves. The ewe restricts her activities, remaining near the lamb to facilitate frequent suckling episodes (Alexander, 1980; Kilgour, 1982). Morgan and Arnold (1974) have noted that most ewes can easily locate and recognise their lambs within a day of birth, but lambs are unable to recognise their dams until they are

several days old. Ewes with lambs up to several days old often will not move far, unless both twins are present (Stevens et al., 1982). They also found that the response of ewes to handling their lambs at tagging varied widely. Most remained within 10 metres or stood beside the observer, but a few ran off and appeared to be searching for their lambs amongst the nearest group of sheep. If one of a twin-set is accidentally separated from a ewe within a minute of birth, then attempts to reunite it with its mother are unlikely to be successful if left for several hours, after which it may be repelled as an alien (Alexander, 1980). The prolonged and difficult birth can adversely affect maternal and lamb behaviour (Alexander, 1960; Shelley, 1970; Haughey, 1975). Exhaustion and injury can adversely delay the bonding of the ewe and the lamb, and affect teat-seeking activity.

However, desertion and pre-lambing maternal interest (stealing) result in only 6 and 10 percent of all lamb losses respectively (Arnold and Morgan, 1975). This suggests that only a small proportion of losses are the direct result of deficient behaviour.

(d) Delivery of the placenta:

Many studies show that the interval from birth to the delivery of the placenta varies widely, being from less than one hour to more than four hours (eg. Arnold and Morgan, 1975; Holmes, 1975). The birth membranes excluding the placenta are usually eaten during the grooming process (90% of ewes). When the placenta is voided all ewes will nose it and lick it, and about a third will eat all, or at least a small portion, of it (Holmes, 1975). Placentophagia does not appear to be related to experience or ingestion of hay, water or concentrate feeds (Holmes, 1975), and is considered normal among herbivores (Herbert, 1972). Primiparous ewes may expel the placenta slightly earlier than multiparous ewes (Holmes, 1975). The weight of the ewes and litter size do not affect the interval after delivery of the last lamb (Owens et al., 1980). Expulsion of the placenta is unaccompanied by pain (Sharafeldin et al., 1971).

D. LAMB MORTALITY

The death of the lamb during the first days of life is a major source of reproductive wastage in sheep flocks. Perinatal mortality includes losses shortly before, during or within 7 days of birth (Haughey, 1980). Lamb mortality is higher in ewes at one year than in older ewes (Dyrmundsson, 1981, review), but the reasons for this have not been established.

Dystocia is caused by the relatively large size of the lamb, or the relatively small size of the dam's pelvic inlet or both (McSporran, 1975; George, 1975). Dystocia is partly related to birthweight (Hight and Jury, 1970; Meyer and Clarke, 1978; Dalton et al., 1980; Duff, 1981). Gordon (1967) indicated that the incidence of mortality in lambs at the same birthweight tends to be higher in hoggets rather than in older ewes. Dystocia may occur also at low birthweights in both single- and multiple-born lambs and is possibly caused by "weak" lambs and ewes, the ewe having poor uterine contractions causing the birth to be slow (Alexander et al., 1959; Alexander and Peterson, 1961; Dalton et al., 1980). Various factors such as birth rank, sex, age of dam, year and breed of sire will influence the incidence of dystocia (Dalton et al., 1980).

Starvation and/or exposure as a cause of lamb mortality have been reviewed by McCutcheon et al. (1981). Several factors are involved with the development of the syndrome of starvation and exposure loss, such as cold stress (Alexander, 1961), ewe-lamb behaviour (Haughey, 1975), central nervous system (CNS) injury (Haughey, 1973a, b), birth weight, sex and birth rank of the lamb (Dalton et al., 1980). It is clear that selection for increased lamb survival and the provision of adequate shelter and shepherding and long-term planning for the arrival of new-born lambs is necessary if improved survival rates are to be achieved under New Zealand pastoral conditions.

E. LACTATION PERFORMANCE

1. Milk Yield

Early studies in New Zealand have indicated that the daily yield for mature Romney ewes can be up to about two litres (Barnicoat et al.,

1949a, b; 1956). Crossbred ewes will usually produce 20-30% more milk than the Romney (Coop and Drew, 1963; Geenty, 1974).

Within 2-4 weeks after parturition the yield reaches a peak and most breeds show similar lactation curves (Barnicoat et al., 1949b; Owen, 1957; Geenty and Jagusch, 1974; Wohlt et al., 1981). Keane (1975a) has indicated that mature ewes reached or had passed their peak yield by approximately 3 weeks after lambing, whereas in ewe hoggets it occurred shortly after the third week of lactation. The milk production of ewes lambing as hoggets is generally lower than that from older animals (Keane, 1975a; Treacher, 1977).

Maximum milk production is dependent on adequate nutrition both during pregnancy and especially in lactation (Barnicoat et al., 1956; Peart, 1967, 1968; Peart et al., 1975; Treacher, 1970; Robinson et al., 1974; Abul-Naga et al., 1981).

The number of lambs suckled will affect milk production. Ewes suckling single lambs produce less milk than those suckling twins but in this comparison rearing-rank and birth-rank is confounded (Geenty, 1979; 1980; Torres-Hernandez and Hohenboken, 1979; Doney et al., 1981; Wohlt et al., 1981). Alexander and Davies (1959) have shown that ewes that produce twins and rear one will produce the same amount of milk as ewes giving birth to and rearing singles.

The sex of the lamb does not affect the milk yield of the ewe (Torres-Hernandez and Hohenboken, 1980; Wohlt et al., 1981).

There is conflict in the results from several studies on the effect of lamb birth weight on milk yield. A positive relationship may exist (Wallace, 1948; Owen, 1957; Scales, 1968), but in other studies no significant correlation was found when yield was estimated following the use of lamb suckling and oxytocin hand-milking or machine-milking techniques (Coombe et al., 1960; Geenty, 1980; Maverogenis, 1982).

2. Milk Composition

The levels of all components of the milk follow similar trends for each breed (Geenty, 1974). Breed differences in percentage composition are small or absent (Barnicoat et al., 1956; Slen et al.,

1963; Addleman et al., 1964), but the stage of lactation affects the composition. Thus, Geenty (1974) found that total solids and fat percentages fell early in lactation (but) then rose during the final weeks as did the solids-not-fat percentage. The protein percentage showed a gradual increase and lactose a decrease as lactation progressed.

Some reports suggested that nutrient composition is not affected by the age of the ewe (Torres-Hernandez and Hohenboken, 1979; Wohlt et al., 1981), however, when large age differences (6 v 2 yr) have been examined then the milk from the older ewes was distinctly and consistently richer than from the young ewes (Barnicoat et al., 1949a).

Levels of nutrition probably interact with a number of factors to affect milk composition. Poor nutrition during pregnancy and lactation significantly increased fat and decreased lactose percentage (Butterworth et al., 1968; Treacher, 1970). Cowan et al. (1981) have concluded that the higher level of protein intake during early lactation increased yields of milk and milk protein and this effect was evident from the second week of lactation. Earlier studies by Barnicoat et al. (1949b) reported that a low plane of nutrition during lactation depressed milk yield and most components with the exception of fat percentage, which increased. The opposite was recorded at high levels of nutrition.

The number of lambs suckled substantially affects the fat and protein content of the milk (Peart et al., 1972). Thus, ewes nursing triplets had the highest percentages of milk fat followed by ewes with twins, and then those suckling singles. This order was reversed for milk protein percentage. Other studies, however, show little or no such effect (Torres-Hernandez and Hohenboken, 1979).

3. Milk Production and Lamb Growth Rate

Few studies have reported on the influence of milk production on lamb growth in different breeds of sheep, and especially in ewe hoggets and in 2-year-old ewes. The correlation between milk production and lamb growth was highest at the start of the lactation period but tended to decline after the first month and as lactation progressed (Barnicoat et al., 1949c; 1956; Slen et al., 1963; Scales, 1968; Geenty and

Jagusch, 1974; Geenty, 1979; Torres-Hernandez and Hohenboken, 1980; Wohlt et al., 1981).

The correlation between weight-gain and milk yield for the entire lactation is usually higher for single lambs than that for twins.

The importance of nutrition during pregnancy and lactation in relation to milk production of ewes and ^{the growth of} their lambs has been amply demonstrated in many studies using high and low planes of nutrition (Barnicoat et al., 1949b; Owen, 1957; Butterworth et al., 1968; Peart, 1967, 1968). These show that the average live weight of lambs on a high plane exceeds those on a low plane of nutrition, and differences are often quite clear especially after the fifth week of lactation. Fat intake and lamb growth are frequently correlated in Romney lambs (Scales, 1968) and significant relationships between protein and solids-not-fat with lamb growth have been reported (Geenty, 1979). Other reports show that while lamb growth and milk components may not be significantly related (Slen et al., 1963; Torres-Hernandez and Hohenboken, 1980; Wohlt et al., 1981), it was noted that the quantity of milk was the major factor influencing the weight-gain of the lambs.

F. EFFECT OF EARLY BREEDING ON LIFETIME PRODUCTION

A major reason often given for not breeding ewe hoggets is that "early" pregnancy detrimentally affects lifetime productive performance. Baker et al. (1981) have reported:

"Reproduction in ewes mated and lambing as ewe hoggets generally has exceeded their contemporaries first joined as two-year-olds by 10% in terms of weaning weight (lamb weaned/ewe joined), by 12% in average weaning weight of lambs, and 20% in terms of weight of lambs weaned." Similar findings have been reported by McCall and Hight (1981). These results appear to be different from those for other breeds reported by Tyrrell(1976), Baker et al. (1978) and Levine et al. (1978), which showed no significant advantage in terms of the number of lambs born or weaned from two-year-old ewes which lambed previously as ewe hoggets. McMillan and McDonald (1983) have shown that net reproductive rate (lamb weaned per ewe joined) appeared enhanced in ewes that had previously weaned a lamb. However, there was no suggestion that hogget lambing affected the reproduction of 2-year-old ewes studied by Moore et al. (1983).

Lamb survival was found to be improved in 2-year-old ewes that lambed as ewe hoggets (Baker et al., 1978; Dalton et al., 1980; McCall and Hight, 1981; McMillan and McDonald, 1983; Moore et al., 1983).

Survival to the end of the 3-year and 4-year lambing of those ewes joined as 2-year-olds was 60% for ewes lambing as ewe hoggets and 62% for controls (Baker et al., 1981).

Ewes that previously lambed as ewe hoggets required less assistance at birth and had better mothering instincts than ewes lambed as 2-year-olds for the first time (Apps, 1953; Boaz, 1960; Lees and Elton, 1978).

A severe maternal handicap was imposed on lambs born to ewe hoggets, and few such animals themselves subsequently lambed at one year of age (McCall and Hight, 1981). A higher percentage of broken-mouth ewes was recorded in 6-year-old ewes (Briggs, 1936). He also indicated that breeding from ewe hoggets resulted in a delay of 2-3 weeks in the time of eruption of the first pair of incisor teeth, the delay being associated with the period of suckling. Well-fed ewe hoggets were not affected.

Fleece weight of ewes at two years of age is also depressed in ewes which had lambed previously compared to unbred ewes (Barker et al., 1978; 1981; Levine et al., 1978; McCall and Hight, 1981; McMillan and McDonald, 1983; Moore et al., 1983).

Evidence from a comprehensive review of literature reported by Dyrmondsson (1973), Baker et al. (1981) and McCall and Hight (1981) concluded that breeding from ewe hoggets can increase the reproductive life of a ewe and enhance lifetime productivity.

G. THE PURPOSE AND SCOPE OF THE INVESTIGATION

The major objectives of this study were to investigate the natural breeding performance of ewe hoggets in comparison with non-bred hoggets and then in turn to determine for all animals their production as 2-year-old ewes under grazing conditions. This entailed allocating each year's group of ewe hoggets (born in 1979, 1980) to either of two groups. The control group comprised about one-third of the animals, and these were kept with vasectomised rams during the breeding season. The remainder of the animals (joined group) were mated to entire Southdown rams. Not all animals in the joined group would be expected to breed as hoggets, but the ^{anticipated} ratio of animals between groups was considered appropriate to generate enough pregnant hoggets for comparative study in that year and subsequently.

During the study, data were collected on several aspects of liveweight growth, mating, pregnancy, parturition and production in the hogget and the 2-year-old ewe. The main observations on the animals and on their lambs were made in the field and during daylight hours. A range of behavioural characteristics of the parturient mother and her lamb at birth were recorded and the data subsequently examined in relation to different factors such as flock (described later), breed and year of study. Data on milk production from both hoggets and ewes were obtained from a sample of the animals which were milked at intervals during the lactation period. This information on milk production was then related to the growth of the lambs suckled by the dams and by others that were not hand-milked. The weaning weights of the lambs were recorded, (although comparison between age of the dams was not possible owing to different times of lambing and other factors). The observations on the crossbred lambs were made until weaning.

CHAPTER THREE

MATERIALS AND METHODS

A. EXPERIMENTAL OUTLINE

A total of 419 ewe hoggets in either August-September 1979 (210) or 1980 (209) were available for the study. They were derived from a randomly-bred flock of Romney ewes mated to either Romney rams or Border Leicester rams maintained at Massey University. Each crop of ewe hoggets was run together up to the start of the observations. These were made on the hoggets and later as two-year-old ewes.

These animals were termed "hoggets" during the calendar year after their birth and "two-year-old ewes" in the succeeding year. Observations were recorded on the animals both as hoggets and as 2-year-old ewes.

B. MANAGEMENT OF EWE HOGGETS AND OBSERVATIONS

Figure 1 provides a calendar of events that occurred with the two crops of animals.

1. Mating.

In each year the ewe hoggets were run with harnessed vasectomised rams initially until mid-April and prior to being allocated into either of the flocks.

Flock 1: Control (not joined to entire rams).

A total of 137 ewe hoggets (70 in 1979, 67 in 1980) was used. The vasectomised rams wore mating harness and crayons with the same colour. Colour marks were checked weekly for a period of four weeks. The colours were changed each 14 days.

Flock 2: Joined (run with entire rams).

A total of 282 ewe hoggets (140 in 1979, 142 in 1980) were studied. Four entire Southdown-Hampshire ram lambs were used in the first year, and four Southdown ram lambs in the second year. These rams carried crayons of different colours (blue, green, red, yellow) so that ewes mated by different rams could be recorded. At the end of a 28-day mating period, both flocks were joined with vasectomised Southdown rams harnessed with crayons to detect "returns" to service. These ewe hoggets were checked once a week for six and two consecutive weeks in 1980 and 1981 respectively.

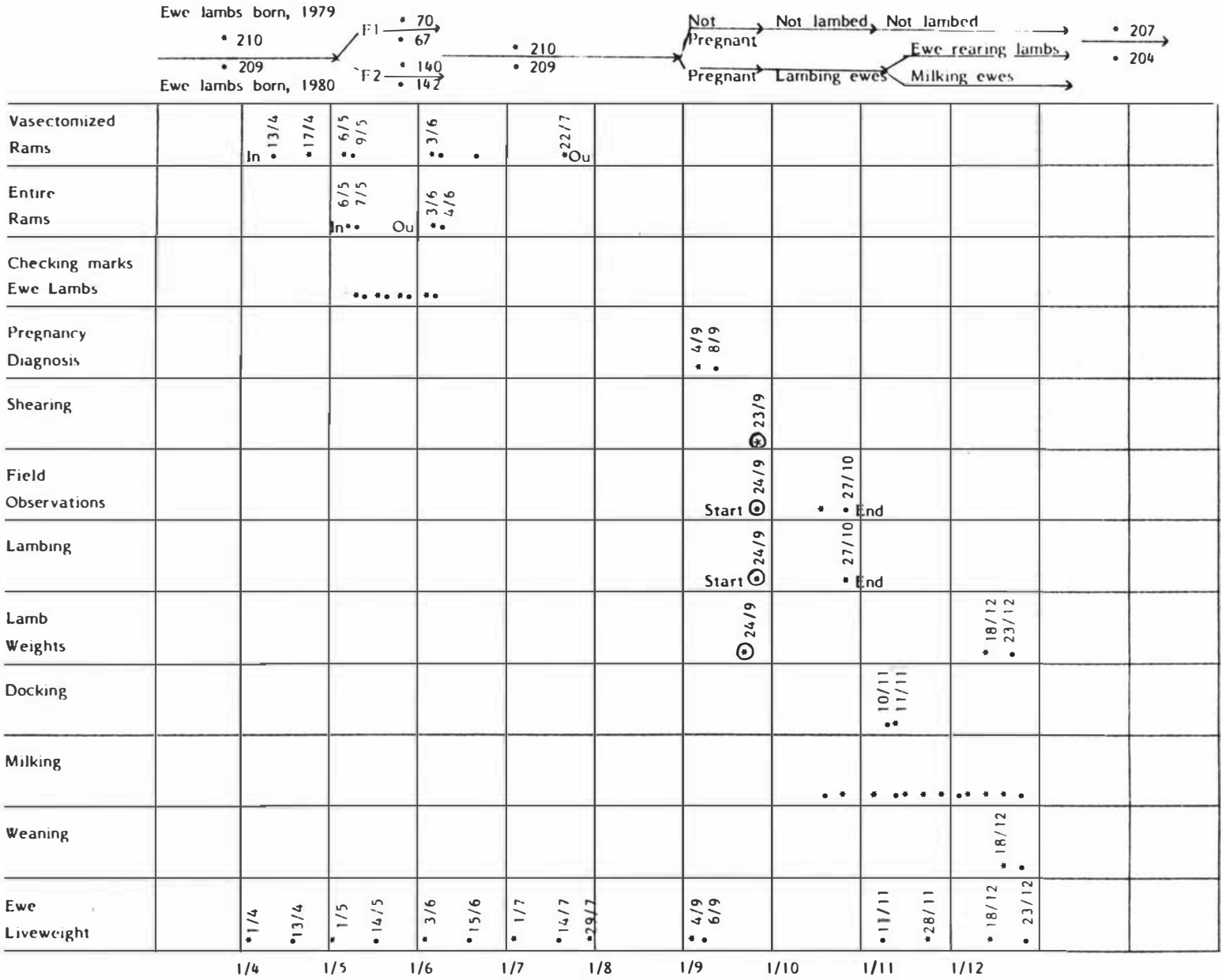


Figure 3.1. Calendar of events for ewe hoggets.

2. Pregnancy Diagnosis.

From 90-120 days after joining with entire rams, the animals were checked for pregnancy using three different methods as follows:-

- i. Crayon marks: Ewes which were marked by ram(s) and which did not return to service were considered to be pregnant.
- ii. Ultrasonic pregnancy detection: The animals were tested using an ultrasonic "Scanopreg" (Lane and Lewis, 1981).
- iii. Visual assessment: The size of the animal and its mammary and genital development was considered in relation to the stage of pregnancy.

3. Lambing Data.

A few days prior to lambing those closest to lambing were separated from non-pregnant animals. All pregnant ewe hoggets were paint-branded mid-side with large numbers. Observations were made between 07.00 - 18.00 h daily for 5 weeks and were made in the paddock or from a caravan. Binoculars (8 x 40⁰) were used when required. Records of lambing behaviour were collected from the time of the first sign of ewe hogget straining until delivery of the placenta occurred. Assistance was given to ewes having prolonged difficulty in lambing (only if the lamb was "presented" for more than 2 hours).

Observations were recorded on a standard protocol sheet as in Appendix 1.

Records were confined to data on the time of an event and "Yes/No" observations. Incidental notes on behaviour and other comments were recorded on the same sheet. Lambs were recorded for breed, sex, birth rank, date and time of lambing. Within 24 h of birth, lambs were weighed (± 0.1 kg) and eartagged. Lamb deaths were recorded.

4. Milk Production.

A group of ewe hoggets suckling single lambs was randomly chosen from those that lambed within a 2-week period.

Initially, 14 animals were milked, and in the second week of milking the number was increased to 24. These animals were kept as a group during the milking period. The first milking occurred 2-3 weeks post-partum and continued once a week for eight weeks until weaning.

In the second year, ewe hoggets were milked each three weeks and initially comprised a group of 16, rising to 28 within 3 weeks.

The number of ewe hoggets milked, breeds, milking interval and year are shown in Table 1.

The ewe hoggets were separated from the lambs just prior to the first milking, after which they were allowed to graze in an adjacent paddock. The second milking was conducted after a 4-hour period and the ewe hoggets were milked in the same order as initially. The animals were milked using a modification of the Oxytocin (2 I.U. injected I.V.) hand-milking method described by McCance (1959). The volume of milk was recorded and the daily milk production was calculated based on the interval between the two milkings.

A 25 ml sample was collected for determination of milk composition. The fat concentration was measured by a Milko-tester Mark III (A/SN Foss Electric, Hillerod, Denmark), and the protein concentration by a Pro-milk III (A/SN Foss Electric, Hillerod, Denmark).

Weaning of the lambs from ewe hoggets occurred on 18 and 21 December in 1980 and 1981 respectively, and lamb weights were recorded.

5. Liveweights and Fleece Weights.

Liveweights of ewe hoggets were recorded as indicated in Figure 3.1.

Greasy fleece weights were obtained (± 0.1 kg) at September shearing.

Table 3.1 Number of ewes, breeds, milking interval and year of milking ewes during the period of experiment.

Classification	Breed		Milking interval	Milking year
	Romney	BLX		
Ewe hoggets (born 1979)	11	13	weekly	1980
Ewe hoggets (born 1980)	14	14	3-weekly	1981
2-year-old ewes (born 1979)	15	16	3-weekly	1981
2-year-old ewes (born 1980)	16	16	3-weekly	1982

C. MANAGEMENT AND OBSERVATIONS ON 2-YEAR-OLD EWES

Figure 3.2 summarizes the observations made on both crops of 2-year-old ewes.

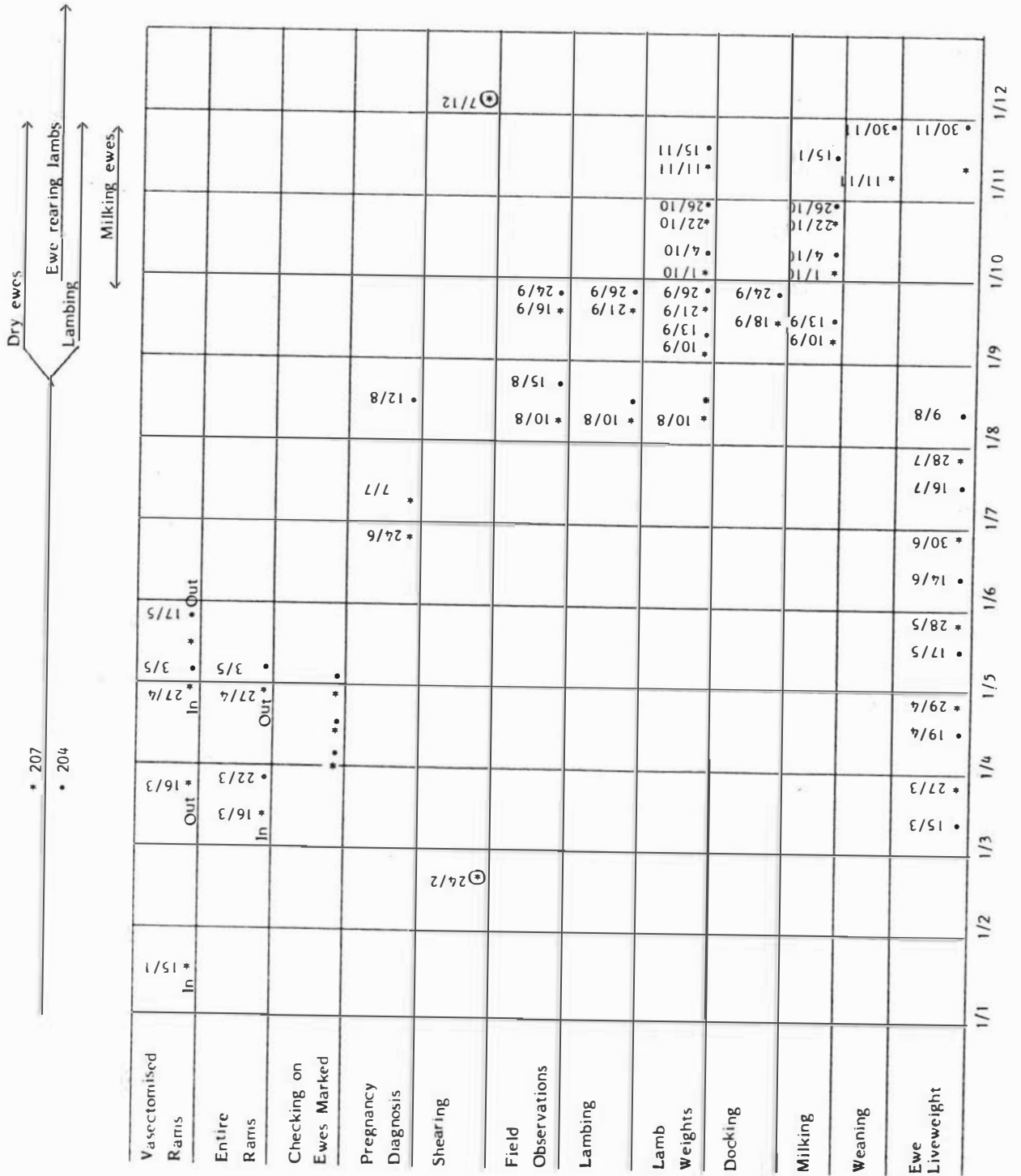
1. Mating: There were 207 and 204 animals available in 1981 and 1982 respectively.

In each year the animals were grazed as one group from the time of weaning as ewe hoggets.

For mating, the animals were joined with 4 entire harnessed Suffolk (1981) or Southdown (1982) rams for 42 days from mid-March. The rams had harnesses with similar colour crayons.

Vasectomised rams were joined with the flock before the entire mating period (1981 only, from mid-January) and for 2 weeks after removal of entire rams. Mating marks were recorded weekly.

Figure 3.2. Calendar of events for two-year-old ewes.



2. Pregnancy diagnosis: All ewes were assessed 90-120 days after joining with entire rams using visual observations and mating records (refer to ewe hoggets).

In 1981, the 2-year-old ewes were also tested using an X-Ray method (operated by staff of the D.S.I.R.). A diagram of the X-Ray machine is shown in Appendix 2.

3. Lambing data: Just prior to lambing the non-pregnant 2-year-old ewes were removed from the flock. The lambing ewes were divided into early lambing and late lambing groups and grazed in adjacent paddocks. As the ewes lambed they and their lambs were drafted off to adjoining paddocks every 2-3 days. Other details were similar to those described for ewe hoggets.

4. Milk production: In each year, the 2-year-old ewes were randomly chosen within breed from those that lambed within a one-week period and were rearing single lambs. Ewes were chosen which reared a lamb for the first time, and others which were in their second lactation. The number of ewes, breeds, milking interval and year are shown in Table 3.1.

Milk production and composition were determined as for the ewe hoggets.

The lambs were weaned from the ewes on 11 and 30 November in 1981 and 1982 respectively.

5. Liveweights and fleece weights: Liveweights of 2-year-old ewes were taken as shown in Figure 3.2.

Greasy fleece weights were obtained (± 0.1 kg) at shearing in February and December in 1981 and 1982 respectively.

D. ANALYSIS OF DATA

The data were analysed using a Generalized Linear Models Computing package (REG), Gilmour (1983). Broadly speaking, two different models were used to analyse the data generated by ewe hoggets and 2-year-old ewes:

- (i) Model 1: included the effects of breed, flock and year; whereas
- (ii) Model 2: included the effects of breed, year and group

[animals were classified into groups on the basis of their reproductive status as hoggets, that is,

- 1 - weaned a lamb (Lambled);
- 2 - marked by teaser (Control);
- 3 - not marked during hogget mating (Acyclic);
- 4 - mated by ram but failed to lamb as hogget (Mated not lambled);
- 5 - lambled but did not wean a lamb (Weaned no Lamb)].

In the case of the hogget data, groups 1 and 5 were combined.

1. Analysis of Continuous Variables

(a) Repeat-measures analyses were conducted assuming an underlying linear model which included breed, flock and year effects, together with appropriate interaction effects.

A model of this general form was considered satisfactory for analyzing liveweight, liveweight gains, milk yield, milk composition and lamb daily growth rate data.

The form of the model used to describe the observation pertaining to the l^{th} individual measured in the p^{th} month of the k^{th} year and belonging to the j^{th} flock in the i^{th} breed was:

$$Y_{pijkl} = \mu_p + A_{ip} + B_{jp} + C_{kp} + (AB)_{ijp} + (AC)_{ikp} + (BC)_{jkp} + e_{ijklp}$$

- where:
- μ_p = the overall mean together with the effect of the p^{th} month;
 - A_{ip} = effect of the i^{th} breed in the p^{th} month;
 - B_{jp} = effect of the j^{th} flock in the p^{th} month;
 - C_{kp} = effect of the k^{th} year in the p^{th} month;
 - $(AB)_{ijp}$ = effect of the interaction of the i^{th} breed and j^{th} flock in the p^{th} month;
 - $(AC)_{ikp}$ = effect of the interaction of the i^{th} breed and k^{th} year in the p^{th} month;
 - $(BC)_{jkp}$ = effect of the interaction of the j^{th} flock and k^{th} year in the p^{th} month;

e_{ijklp} = random residual effect specific to $ijkl$ combination of breed, flock, year and month; in the p^{th} month. On a within-month basis residuals were assumed to be individually and independently distributed, there being covariances amongst residuals across months.

In the analyses pertaining to the repeat-measure models, null hypotheses were tested using the Chi-squared statistic, the basis for so doing being fully described in Section 5.8 of Morrison (1976).

(b) Univariate Analysis. The general form of the linear model used to analyse ewe fleece weight, day of birth for hoggets and 2-year-old ewes was:

$$Y_{ijkl} = \mu + A_i + B_j + C_k + (AB)_{ij} + (AC)_{ik} + (BC)_{jk} + e_{ijkl}$$

where: μ = the overall mean;
 A_i = the effect of i^{th} breed, $i = 1,2$
 B_j = the effect of j^{th} flock, $j = 1,2$
 C_k = the effect of k^{th} year, $k = 1,2$
 $(AB)_{ij}$ = the effect of interaction of the i^{th} breed and j^{th} flock
 $(AC)_{ik}$ = the effect of interaction of the i^{th} breed and k^{th} year
 $(BC)_{jk}$ = the effect of interaction of the j^{th} flock and k^{th} year
 e_{ijkl} = the random error effect.

Higher order interaction effects were assumed negligible.

The general form of the linear model used to analyse birth weight, weaning weight and daily growth rate was:

$$Y_{ijklmn} = \mu + b(X_{ijklm}) + A_i + D_l + E_m + B_j + C_k + (AD)_{il} + (AE)_{im} + (AB)_{ij} + (AC)_{ik} + (DE)_{lm} + (DB)_{lj} + (DC)_{lk} + (EB)_{mj} + (EC)_{mk} + (BC)_{jk} + e_{ijklmn}$$

where: μ , A_i , B_j , C_k , $(AB)_{ij}$, $(AC)_{ik}$ and $(BC)_{jk}$ as defined previously;

D_l = effect of the l^{th} lamb rank, $l = 1, 2$
 E_m = effect of the m^{th} sex of lamb, $m = 1, 2$
 $b(X_{ijklm})$ = regression coefficient on birth day.

$(AD)_{il}$, $(AE)_{im}$, $(DE)_{lm}$, $(DB)_{lj}$, $(DC)_{lk}$, $(EB)_{mj}$, $(EC)_{mk}$ are correspondingly defined.

e_{ijklmn} = random residual effect.

2. Analysis of Discrete Variables

Models of the same general form as those used in analysing continuous data were fitted in order to construct analyses of deviance. The deviances are distributed as Chi-square variables. The analyses of deviance were generated by applying the method of iterative re-weighted least squares together with the logit transformation which is given by

$$\text{logit}(p) = \ln(p/1 - p)$$

where p is the proportion of individuals responding at one of the two levels of the variate. The ratio $(p/1 - p)$ is commonly referred to as the odds ratio.

Occurrence versus non-occurrence of oestrus in hoggets is a typical binary variable representing these kinds of analyses. Discrete data measured over time were transformed using the logarithmic transformation to correct for skewness.

Tests of significance were performed under the transformed scale, but for ease of interpretation, least squares estimates of treatment effects were back-transformed to the original scale.

Levels of significance are denoted throughout by the letters assigned to means on the basis of Duncan's multiple range test; means with letters not in common are significantly different and the level of significance is given in the text.

The following abbreviations are used to denote the levels of statistical significance used in analysis of variance tables:

NS = Not significant or $p > 0.05$
 * = $p < 0.05$
 ** = $p < 0.01$
 *** = $p < 0.001$

CHAPTER FOUR

RESULTS

1. PRODUCTION OF EWE HOGGETS AND TWO-YEAR-OLD EWES

1a. Ewe Hoggets

1a.1 Liveweight: Mean liveweights are presented in Table 4.1 and Figure 4.1.

Examination of the analyses pertaining to the first model showed that there were significant differences in the liveweight for the different months ($P < 0.001$). There were significant effects for breed ($P < 0.001$) and year ($P < 0.001$) on the liveweight, but the effect of flock was not significant. The results also showed that Romney and BLX hoggets differ significantly ($P < 0.001$) across months. Similar results were obtained for months-by-flock ($P < 0.001$) and months-by-year ($P < 0.001$). A significant interaction was revealed by the analysis between months and flock-by-year ($P < 0.05$).

Results of fitting the second model indicated that the effects of months, breed, and year were similar to those obtained in the first model as shown in Table 4.2. The effect of groups on liveweight was significant ($P < 0.01$). In addition, the analysis showed that there was a significant interaction between months and groups ($P < 0.001$). Although the main factors were significant, the analysis disclosed a significant interaction between months and year-by-group ($P < 0.001$).

May weighing.

Overall May bodyweight was 36.6 kg. Hoggets which did not cycle (Acyclic) during the mating period had lighter body weights compared to the other three groups ($P < 0.01$). Differences between the other three groups were not significant.

July weighing.

Similar results to the May weighing were obtained. July body weight averaged 41.3 kg.

September weighing.

September weighing showed that hoggets which lambed were significantly ($P < 0.01$) heavier than the other groups. The acyclic group versus both control and hoggets mated but not lambed groups were

significant ($P < 0.01$).

November weighing.

Weighing the animals after lambing showed that hoggets that lambed had lost weight compared to the other three groups which gained weight. Nevertheless the acyclic group was still the lighter group. The difference between acyclic versus lambing groups was significant ($P < 0.05$). Acyclic versus both control and hoggets mated but not lambed were also significant ($P < 0.01$). November weighing averaged 48.0 kg.

December weighing.

December body weights averaged 49.6 kg. Hoggets lambed were found to have significantly the lighter body weights compared to the other three groups. The acyclic group versus both control and hoggets mated but not lambed were significant ($P < 0.05$).

1a.2 Hogget weight gains: Changes in liveweight gain in hoggets were analysed for May-July, July-September, September-November and November-December.

The statistical analysis for model 1 is presented in Table 4.3. Examination of the results indicates that differences in weight gains over months were significant ($P < 0.001$). The results also showed that there were significant differences between breeds ($P < 0.001$), flock ($P < 0.001$) and between year ($P < 0.001$). Breed differences were not constant across the months ($P < 0.05$). Similar results were obtained for flocks across months ($P < 0.001$) and year across months ($P < 0.001$). A significant interaction between months and flock-by-year was revealed by the analysis ($P < 0.05$).

Similarly the comparable results for model 2 are given in Table 4.4 and Figure 4.2. The analysis showed that there were significant differences between months ($P < 0.001$), breed ($P < 0.001$), year ($P < 0.001$) and groups ($P < 0.001$). However, breed differences were not constant across months, i.e. there was a month-by-breed interaction ($P < 0.01$). The results also showed significant interaction between some factors, notably between months-by-year ($P < 0.001$), months-by-group ($P < 0.001$) and months-by-year-by-group ($P < 0.01$).

Table 4.1. Breed, flock and year least squares means (and standard error) for the live weights (kg) of hoggets

Classification	Number	May	July	September	November	December
Overall	413	36.7 ± 0.2	41.6 ± 0.2	45.0 ± 0.3	48.1 ± 0.2	49.8 ± 0.3
<u>Breed</u>						
Romney	176	34.9 ± 0.3	39.5 ± 0.3	42.6 ± 0.4	45.5 ± 0.4	47.3 ± 0.4
BLX	237	38.5 ± 0.3	43.7 ± 0.3	47.5 ± 0.3	50.7 ± 0.3	52.4 ± 0.3
<u>Flock</u>						
Control	137	36.6 ± 0.4	41.8 ± 0.4	44.3 ± 0.4	48.3 ± 0.4	50.9 ± 0.4
Joined	276	36.8 ± 0.2	41.4 ± 0.2	45.8 ± 0.3	47.9 ± 0.3	48.8 ± 0.3
<u>Year</u>						
1979	208	34.9 ± 0.3	42.1 ± 0.3	42.8 ± 0.4	46.2 ± 0.3	48.8 ± 0.4
1980	205	38.5 ± 0.3	41.2 ± 0.3	47.2 ± 0.4	50.0 ± 0.4	50.9 ± 0.4

Table 4.1 (continued).

Repeated-measurements analysis of variance

Source of variation	DF	Chi-square	Significance
Months	4	1146.6	***
Breed	1	138.4	***
Flock	1	0.1	NS
Year	1	43.6	***
Breed x flock	1	0.1	NS
Breed x year	1	1.1	NS
Flock x year	1	0.7	NS
Months x breed	4	38.4	***
Months x flock	4	76.6	***
Months x year	4	484.2	***
Months x breed x flock	4	2.3	NS
Months x breed x year	4	7.9	NS
Months x flock x year	4	11.5	*

Number of observations per month - 413

Figure 4-1 Live weight (kg) of ewe hoggets

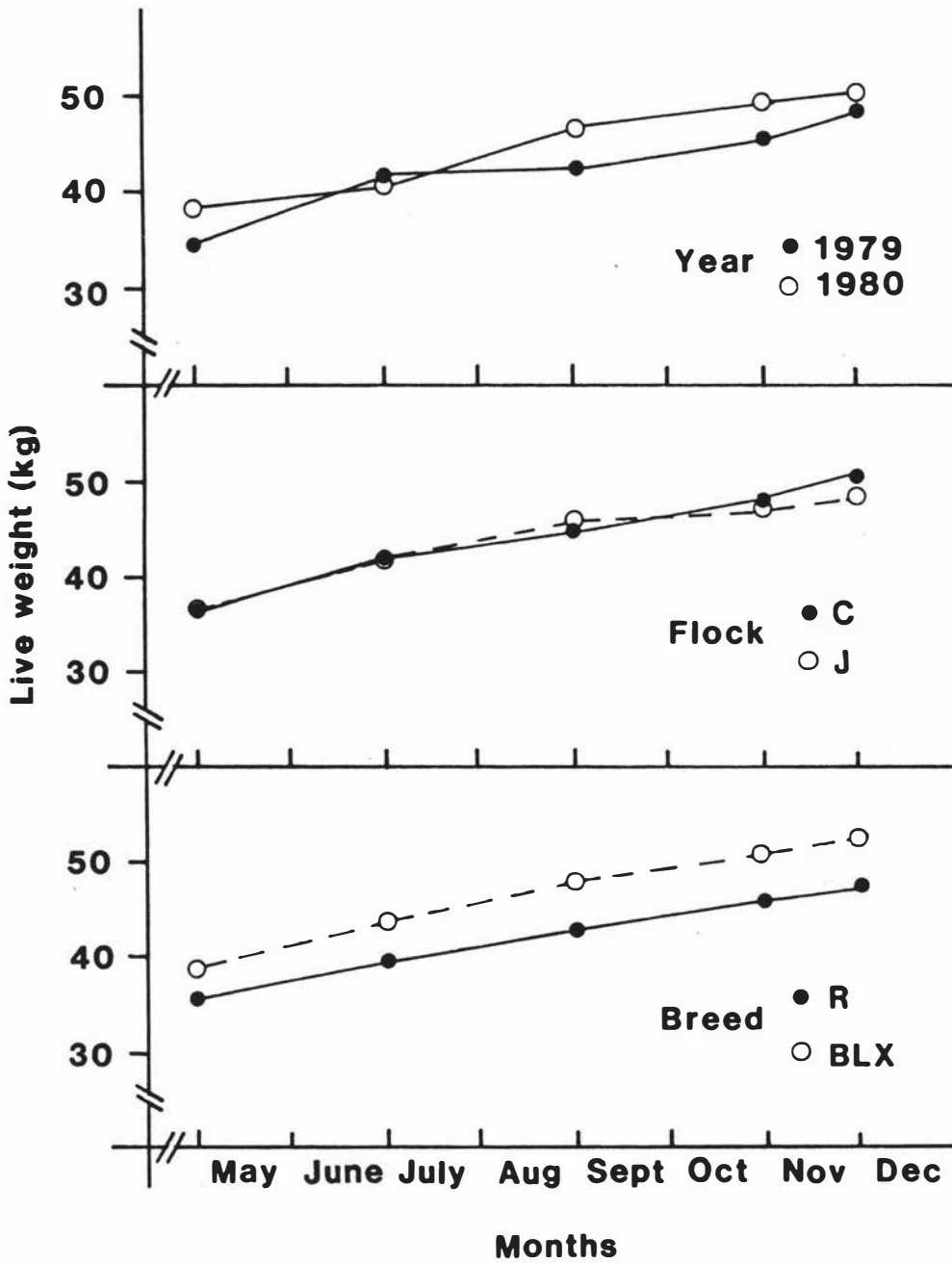


Table 4.2. Breed, year and group least squares means (and standard error) for the liveweights (kg) of hoggets.

Classification.	Number	May	July	September	November	December
Overall	413	36.6 \pm 0.2	41.3 \pm 0.2	44.9 \pm 0.2	48.0 \pm 0.2	49.6 \pm 0.3
<u>Breed</u>						
Romney	176	34.8 \pm 0.3	39.2 \pm 0.3	42.5 \pm 0.3	45.4 \pm 0.4	46.9 \pm 0.4
BLX	237	38.5 \pm 0.3	43.5 \pm 0.3	47.2 \pm 0.3	50.7 \pm 0.3	52.4 \pm 0.3
<u>Year</u>						
1979	208	34.7 \pm 0.3	41.9 \pm 0.3	42.7 \pm 0.3	46.0 \pm 0.3	48.4 \pm 0.3
1980	205	38.6 \pm 0.3	40.8 \pm 0.3	47.0 \pm 0.3	50.0 \pm 0.3	50.9 \pm 0.4
<u>Group</u>						
Lambled	136	37.3 \pm 0.3A	42.1 \pm 0.4A	48.1 \pm 0.4A	47.8 \pm 0.4C	47.1 \pm 0.4B
Control	121	37.0 \pm 0.4A	42.1 \pm 0.4A	44.5 \pm 0.4DC	48.5 \pm 0.4AC	51.2 \pm 0.5A
Acyclic	69	34.8 \pm 0.5B	39.6 \pm 0.5B	42.3 \pm 0.5B	46.9 \pm 0.6B	49.7 \pm 0.6C
Mated not lambled	87	37.6 \pm 0.4A	41.6 \pm 0.4A	44.5 \pm 0.5C	48.8 \pm 0.5AC	50.6 \pm 0.5A

Table 4.2 (continued).

Repeated-measurements analysis of variance			
Source of variation	DF	Chi-square	Significance
Months	4	1148.7	***
Breed	1	140.5	***
Year	1	44.4	***
Group	3	12.7	**
Breed x year	1	1.0	NS
Breed x group	3	1.7	NS
Year x group	3	1.3	NS
Months x breed	4	40.4	***
Months x year	4	501.2	***
Months x group	12	307.2	***
Months x breed x year	4	8.1	NS
Months x breed x group	12	12.4	NS
Months x year x group	12	32.2	***

Number of observations per month - 413

Table 4.3. Breed, flock and year least squares means (and standard error) for the weight gains (kg) of hoggets.

Classification	Number	May - July	July-September	September-November	November-December
<u>Overall</u>	413	4.9 \pm 0.1	3.4 \pm 0.1	3.1 \pm 0.2	1.7 \pm 0.2
<u>Breed</u>					
Romney	176	4.6 \pm 0.2	3.1 \pm 0.2	2.9 \pm 0.3	1.8 \pm 0.3
BLX	237	5.2 \pm 0.1	3.8 \pm 0.2	3.2 \pm 0.3	1.7 \pm 0.2
<u>Flock</u>					
Control	137	5.3 \pm 0.2	2.4 \pm 0.2	4.0 \pm 0.3	2.6 \pm 0.3
Joined	276	4.5 \pm 0.1	4.4 \pm 0.2	2.2 \pm 0.2	0.8 \pm 0.2
<u>Year</u>					
1979	208	7.1 \pm 0.1	0.8 \pm 0.2	3.4 \pm 0.2	2.6 \pm 0.2
1980	205	2.7 \pm 0.2	6.1 \pm 0.2	2.8 \pm 0.3	0.8 \pm 0.2

Table 4.3 (continued).

Repeated-measurements analysis of variance			
Source of variation	DF	Chi-square	Significance
Months	3	258.2	***
Breed	1	12.5	***
Flock	1	27.8	***
Year	1	12.3	***
Breed x flock	1	0.0	NS
Breed x year	1	2.6	NS
Flock x year	1	0.4	NS
Months x breed	3	9.4	*
Months x flock	3	74.4	***
Months x year	3	484.1	***
Months x breed x flock	3	2.0	NS
Months x breed x year	3	3.5	NS
Months x flock x year	3	11.5	*

Number of observations per month - 413

Table 4.4. Breed, year and group least squares means (and standard error) for the weight gains (kg) of hoggets.

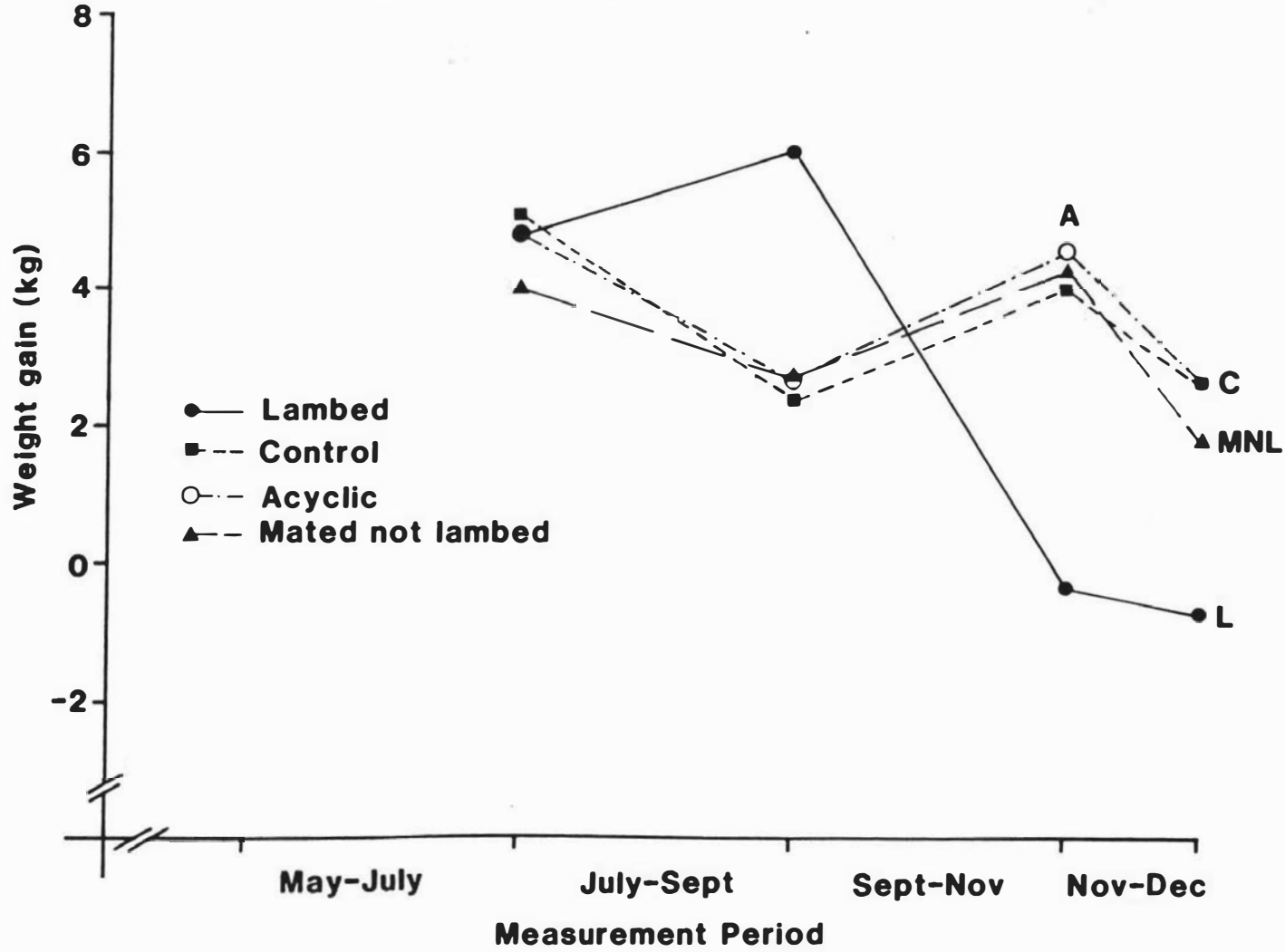
Classification	Number	May - July	July-September	September-November	November-December
<u>Overall Breed</u>	413	4.7 \pm 0.1	3.5 \pm 0.1	3.2 \pm 0.2	1.6 \pm 0.1
Romney	176	4.4 \pm 0.2	3.3 \pm 0.2	2.9 \pm 0.2	1.5 \pm 0.2
BLX	237	5.0 \pm 0.1	3.7 \pm 0.2	3.4 \pm 0.2	1.7 \pm 0.2
<u>Year</u>					
1979	208	7.2 \pm 0.1	0.8 \pm 0.2	3.3 \pm 0.2	2.4 \pm 0.2
1980	205	2.2 \pm 0.1	6.2 \pm 0.2	3.0 \pm 0.2	0.9 \pm 0.2
<u>Group</u>					
Lambled	136	4.8 \pm 0.2A	6.0 \pm 0.2A	-0.3 \pm 0.3B	-0.7 \pm 0.2B
Control	121	5.1 \pm 0.2 A	2.4 \pm 0.2BE	4.0 \pm 0.3CE	2.7 \pm 0.3CE
Acyclic	69	4.9 \pm 0.2A	2.7 \pm 0.3CE	4.6 \pm 0.4AE	2.8 \pm 0.3AE
Mated not lambled	87	4.0 \pm 0.2B	2.9 \pm 0.2DE	4.3 \pm 0.3DE	1.8 \pm 0.3D

Table 4.4 (continued).

Repeated-measurements analysis of variance			
Source of variation	DF	Chi-square	Significance
Months	3	301.4	***
Breed	1	15.0	***
Year	1	15.6	***
Group	1	100.5	***
Breed x year	1	2.5	NS
Breed x group	3	4.6	NS
Year x group	3	5.0	NS
Months x breed	3	12.8	**
Months x year	3	501.8	***
Months x group	9	295.7	***
Months x breed x year	3	3.8	NS
Months x breed x group	9	6.0	NS
Months x year x group	9	26.3	**

Number of observations per month - 413

Figure 4-2 Changes in liveweight gain in ewe hoggets



May-July.

Hoggets mated but barren differ significantly from lambed ($P < 0.01$), control ($P < 0.01$) and acyclic ($P < 0.05$) groups respectively. Overall weight gain was 4.7 kg.

July-September.

Average weight gain for July-September was 3.5 kg. The lambed group gained significantly more weight than the other three groups ($P < 0.01$).

September-November.

Hoggets which lambed lost weight compared to the other groups which gained weight ($P < 0.01$).

November-December.

At the time of weaning, hoggets which lambed appeared to have lost more weight, while the other groups gained weight ($P < 0.01$).

1a.3 Incidence of oestrus: Table 4.5 shows the percentage of ewe hoggets in oestrus classified according to breed, flock and year. Overall, oestrus occurred in about 83% of the animals studied. The flock effect was significant ($P < 0.05$), but this is surprising in view of the animals being chosen at random. Breed of hoggets was not significant but the difference in incidence of oestrus was as anticipated.

1a.4 Conception: A ewe was considered to have conceived if it delivered a lamb either prematurely or otherwise.

Data for animals classified for breed, year and ram intensity (whether marked by one ram or more rams) and the associated analyses for hogget marked or joined are presented in Table 4.6. The data were adjusted for May to June weight gain.

Hoggets marked.

There was a significant difference in conception rate between breeds ($P < 0.05$). A greater proportion of BLX hoggets conceived compared to the Romneys. Differences between years and also between hoggets marked by one or more rams were not significant. The analysis showed a significant weight-gain-by-year interaction ($P < 0.05$). The regression of conception on weight gain was not constant across years ($P < 0.05$) and therefore, interpretation of the results generated by the analysis of covariance is complicated. The overall

conception rate for hoggets marked was 60.6%.

Hoggets joined.

The proportion of BLX hoggets that conceived was significantly ($P<0.05$) greater than that for Romney hoggets. Hoggets marked by more than one ram had a higher pregnancy rate than those marked by only one ram ($P<0.01$). The overall conception rate per hogget joined was 43.2%.

Conception to first service and all services and the effects of breed and year are shown in Table 4.7. Overall conception rate to first service was 75.4%. The only significant difference revealed by the analysis was between breeds ($P<0.01$) in favour of the BLX hoggets.

Similar analysis was carried out on the data of all services and the overall conception rate was 63.6%. The analysis of the data indicated that breeds were significantly ($P<0.05$) different. Although there was a difference between years, this was not statistically significant. An interaction between year and weight gain ($P<0.05$) was disclosed by the analysis. The regression of conception on weight gain was not constant across years ($P<0.05$) and therefore, interpretation of the results generated by the analysis of covariance is complicated.

Table 4.8 presents the effects of breed and year on conception to first service and to all services based on hoggets joined.

Overall conception for first service was 32.2%. The results obtained by the analysis showed that the only significant difference was the interaction between weight gains and year. The regression of conception on weight gain was not constant across years ($P<0.05$) and therefore, interpretation of the results generated by the analysis of covariance was difficult. Differences between breeds and between years were not significant.

The analysis of data for all services revealed a significant difference between breeds ($P<0.05$). Overall conception for all services was 48.6%.

Table 4.5. Effects of breed, flock and year on the incidence of oestrus in hoggets.

Classification	Number	In oestrus (%)
Overall	419	82.6
<u>Breed</u>		
Romney	178	79.2
BLX	241	85.5
<u>Flock</u>		
Control	137	88.3
Joined	282	80.1
<u>Year</u>		
1979	210	81.4
1980	209	84.2

Source of variation	Analysis of deviance	
	DF	Deviance
Breed	1	2.79 NS
Flock	1	3.99 *
Year	1	0.43 NS
Breed x flock	1	3.34 NS
Breed x year	1	0.39 NS
Flock x year	1	0.23 NS
Residual	412	373.28

Table 4.6. The effect of breed, year and ram intensity on the conception rate.

Classification	Number joined	Marked		Number of hoggets lambing	Conception rate	
		Number	%		Marked	Joined
<u>Overall</u>	282	226	80.1	139	60.6	43.2
<u>Breed</u>						
Romney	129	102	79.1	54	43.0	32.2
BLX	153	124	81.0	85	75.8	54.9
<u>Year</u>						
1979	140	111	79.3	64	67.7	44.5
1980	142	115	81.0	75	53.0	42.0
<u>Ram marked no.</u>						
One ram	282	71	25.2	40	41.8	23.2
More than one		155	55.2	99	76.7	65.8

Table 4.6 (continued)

Source of variation	DF	Analysis of deviance	
		Hoggets	
		Marked Deviance	Joined Deviance
Weight gain	1	0.11	0.20
Breed	1	5.73 *	5.23 *
Year	1	1.28 NS	1.08 NS
Ram marked no.	1	2.38 NS	8.66 **
Wt. gain x breed	1	0.56 NS	0.65 NS
Wt. gain x year	1	4.47 *	3.01 NS
Wt. gain x ram marked no.	1	1.71 NS	0.33 NS
Breed x year	1	0.05 NS	0.05 NS
Breed x ram marked no.	1	0.93 NS	0.20 NS
Year x ram marked no.	1	0.66 NS	1.60 NS
Residual	215	283.36	369.88 (271 D.F.)

Table 4.7. Effect of breed and year on conception to first service and to all services based on hoggets marked.

Classification	Number	<u>Conception rate</u>		
		First service	Number	All services
Total	149	75.4	226	63.6
<u>Breed</u>				
Romney	70	43.2	102	47.3
BLX	79	92.5	124	77.2
<u>Year</u>				
1979	77	86.6	111	74.7
1980	72	59.2	115	50.8

Analysis of deviance

Source of variation	DF	<u>Deviance</u>	
		First service	All services
Weight gain	1	0.85	0.11
Breed	1	7.74 **	5.73 *
Year	1	0.21 NS	1.28 NS
Weight gain x breed	1	2.62 NS	0.43 NS
Weight gain x year	1	2.66 NS	4.59 *
Breed x year	1	0.44 NS	0.10 NS
Residual	142	174.22	288.99 (219 DF)

Table 4.8. Effects of breed and year on conception to first service and to all services based on hoggets joined.

Classification	Number	Conception Rate	
		First service	All services
Total	282	32.2	48.6
Breed			
Romney	129	22.2	38.1
BLX	153	44.0	59.2
Year			
1979	140	42.9	55.3
1980	142	23.1	41.9

Source of variation	DF	Analysis of deviance	
		First service	All services
Weight gain (May-June)	1	0.09	0.20
Breed	1	2.88 NS	5.23 *
Year	1	0.58 NS	1.08 NS
Weight gain x breed	1	1.32 NS	0.40 NS
Weight gain x year	1	5.06 *	3.20 NS
Breed x year	1	0.00 NS	0.00 NS
Residual	275	356.81	380.76

1a.5 Pregnancy diagnosis: A total of 282 ewe hoggets and 411 two-year-old ewes were examined for pregnancy using the several methods already described. The results of the diagnosis were later compared with actual lambing records.

Appendix 3 presents the results of pregnancy diagnosis for each of the methods used and also detection of foetal number using the X-Ray method.

1a.6 Day of birth: Table 4.9 shows the means for day of birth for ewe hoggets and the analysis of the effects of breed and year.

There were no significant differences between breeds nor between years.

1a.7 Incidence of multiple births: Table 4.10 shows the incidence of multiple births, classified according to breed and year.

The BLX hoggets had a higher twinning rate than Romney hoggets, the incidence being similar across years. Overall the incidence of twinning was 6%.

1a.8 Weaning percentage: Table 4.11 presents the percentage of hoggets weaning lambs and the effects of different factors.

Weaned one lamb.

The analysis of the data showed that there were no significant differences between breeds and between years in weaning rate.

Weaned twin lambs.

Only a few hoggets produced twins and there were insufficient animals to permit meaningful analysis of the data.

All weaned lambs.

The weaning percentage based on the number of hoggets joined was 44%. The BLX hoggets weaned significantly ($P < 0.05$) more lambs (12%) than Romney hoggets. There was no effect of the year on weaning rate.

Table 4.9. Effects of breed and year on the day of birth in hoggets.

Classification	Number	Mean \pm S.E.
Overall	139	285.3 \pm 0.8
<u>Breed</u>		
Romney	54	284.9 \pm 1.2
BLX	85	285.6 \pm 1.0
<u>Year</u>		
1979	64	285.7 \pm 1.1
1980	75	184.8 \pm 1.1

Source of variation	Analysis of variance	
	DF	Mean square
Breed	1	9.98 NS
Year	1	63.86 NS
Breed x year	1	159.71 NS
Error	135	79.16 NS
Total	138	

Table 4.10. Incidence of multiple births in hoggets.

Classification	Number	Incidence of twinning (%)
Overall	282	6.4
<u>Breed</u>		
Romney	129	3.1
BLX	153	9.2
<u>Year</u>		
1979	140	6.4
1980	142	6.3

Table 4.11. Effects of breed and year on the incidence of hoggets weaning one and two lambs.

Classification	Number	Weaned one lamb (%)	Weaned two lambs (%)	LW/EJ ^a (%)
Overall	282	37	4	44
<u>Breed</u>				
Romney	129	32	3	38
BLX	153	42	4	50
<u>Year</u>				
1979	140	35	4	44
1980	142	39	3	45

Source of variation	DF	Analysis of deviance	
		<u>Deviance</u>	LW/EJ
Breed	1	3.04 NS	4.41 *
Year	1	0.37 NS	0.09 NS
Breed x year	1	0.06 NS	0.03 NS
Residual	278	368.88	376.76

a - Lamb weaned per ewe joined.

1a.9 Fleece production: A total of 417 hoggets was present at shearing in September.

Table 4.12 presents the mean (\pm S.E.) for fleece weight and the associated analysis of the effects of breed, flock and year.

There was a significant effect of breed ($P < 0.001$), the BLX animals producing (200 g) more than the Romneys.

Table 4.13 shows the analysis of the fleece data when the influence of the hoggets reproductive history (groups) is included. This analysis showed only the breed effect to be significant ($P < 0.001$).

Between the four group levels, the mean fleece weights varied between (4.07 - 4.21 kg) but hoggets which had lambed had slightly lower fleece weights than the control animals. The difference was not significant. The animals which did not cycle had even lower fleece weights than the lambed hoggets but the difference was not significant. It should be noted that non-cyclic hoggets were the lightest of the four groups at the September weighing.

1b. Two-year-old ewes

1b.1 Liveweights: The analysis of liveweight for 2-year-old ewes was carried out on selected months: March, July and November, and similar methods to those used for hogget liveweights were applied.

Mean liveweights are presented in Table 4.14 and Figure 4.3.

Results pertaining to the first model showed that there were significant differences between months ($P < 0.001$). There were significant effects for breed ($P < 0.001$), flock ($P < 0.001$) and year ($P < 0.01$) on the liveweights. Although the effects of main factors were significant, the analysis also revealed significant months-by-breed ($P < 0.05$), months-by-flock ($P < 0.01$), months-by-year ($P < 0.001$) and breed-by-year ($P < 0.05$) interactions.

Table 4.15 presents the results of fitting the second model which includes the effects of breed, year and group (five levels).

Table 4.12. Effects of breed, flock and year on hogget fleece weight (kg).

Classification	Number	Fleece weight (mean \pm S.E.)
Overall	417	4.16 \pm 0.02
<u>Breed</u>		
Romney	176	4.06 \pm 0.04
BLX	241	4.26 \pm 0.03
<u>Flock</u>		
Control	136	4.20 \pm 0.04
Joined	281	4.13 \pm 0.03
<u>Year</u>		
1979	208	4.12 \pm 0.03
1980	209	4.20 \pm 0.04

Source of variation	Analysis of variance	
	DF	Mean square
Breed	1	5.36 ***
Flock	1	0.29 NS
Year	1	0.32 NS
Breed x flock	1	0.13 NS
Breed x year	1	0.05 NS
Flock x year	1	0.22 NS
Error	410	0.20
Total	416	

Table 4.13. Effects of breed, year and group on hogget fleece weights (kg).

Classification	Number	Fleece weight (mean \pm S.E.)
Overall	417	4.14 \pm 0.02
<u>Breed</u>		
Romney	176	4.03 \pm 0.04
BLX	241	4.26 \pm 0.03
<u>Year</u>		
1979	208	4.13 \pm 0.03
1980	209	4.16 \pm 0.03
<u>Group</u>		
1. Lambed	139	4.12 \pm 0.04A
2. Control	120	4.21 \pm 0.04A
3. Acyclic	69	4.07 \pm 0.05A
4. Mated not lambed	89	4.18 \pm 0.05A

Source of variation	Analysis of variance	
	DF	Mean square
Breed	1	5.36 ***
Year	1	0.31 NS
Group	3	0.29 NS
Breed x year	1	0.04 NS
Breed x group	3	0.10 NS
Year x group	3	0.22 NS
Error	404	0.20
Total	416	

Differences between months were significant ($P < 0.001$), the effect of breed was significant ($P < 0.001$) and so too was the effect of group ($P < 0.001$). Year effects were not significantly different (Figure 4.4). Significant interaction effects between breed and months ($P < 0.05$), months-by-year ($P < 0.001$), months-by-group ($P < 0.001$) and breed-by-year interaction ($P < 0.05$) were revealed by the analysis.

March weighing.

Overall March body weight was 47.5 kg. Ewes lambing as hoggets and weaned lamb(s) differed significantly from the other four groups ($P < 0.01$).

July weighing.

The July body weight average was 47.4 kg. Results obtained were similar to the results of the March weighing.

November weighing.

At the time of weaning the lambs from the 2-year-old ewes, ewes which lambing as hoggets were significantly lighter in body weight ($P < 0.01$) compared to the other groups.

1b.2 Weight gain in two-year-old ewes: Changes in weight gain in 2-year-old ewes were analysed for March-April, April-May, May-June, June-July and July-November. Similar models used to analyse the liveweights were used to analyse the weight gains.

The statistical analysis pertaining to model one is presented in Table 4.16.

Generally the results obtained for weight gains were the same as those found from fitting the first model for liveweights.

Table 4.17 presents the analogous results for model 2 classified according to breed, year and group. There were significant differences between months ($P < 0.001$), breed ($P < 0.05$), year ($P < 0.001$) and between groups ($P < 0.001$). Examination of the results showed that there were significant interactions between months and breed ($P < 0.05$), between months and year ($P < 0.001$) and also between months and breed-by-year ($P < 0.01$).

March-April.

The two-year-old ewes which weaned lamb(s) as hoggets gained more weight than the other groups.

The ewes which lambed as hoggets and weaned lamb(s) had weight gain changes which differed significantly to those of animals in the control group ($P < 0.01$) and in the lambed but not weaned a lamb group ($P < 0.05$).

April-May.

Overall average April-May weight gains were 0.37 kg. Differences between groups were not significant.

May-June.

Ewes started to lose weight. The overall average loss in weight was 2.13 kg. Between-groups differences were not significant.

June-July.

There were no significant differences between groups, and overall weight gain was 0.33 kg.

July-November.

Although two-year-old ewes which lambed as hoggets gained significantly ($P < 0.01$) more weight than hoggets in other groups, they were still the lightest group compared to other groups.

1b.3 Incidence of oestrus: Table 4.18 shows the percentage of oestrus in the first cycle and during all cycles of ^{the} mating period classified according to breed, flock and year in the first model, while in the second model the effects of breed, year and group (five levels) were studied.

Results from the analysis of the first model showed that the only significant difference was between years ($P < 0.001$) in the first cycle. There were no significant differences between factors in the analysis of all cycles.

Similar results were obtained when the second model was examined for both first cycle and all cycles. Differences between groups were small.

Table 4.14. Breed, flock and year least squares means (and standard error) for the liveweights(kg) of 2-year-old ewes.

Classification	Number	March	April	May	June	July	November
Overall	404	47.5 \pm 0.3	48.8 \pm 0.3	49.1 \pm 0.3	47.0 \pm 0.3	47.3 \pm 0.3	57.8 \pm 0.3
<u>Breed</u>							
Romney	173	44.7 \pm 0.4	45.9 \pm 0.4	46.3 \pm 0.4	44.3 \pm 0.4	44.7 \pm 0.4	55.4 \pm 0.5
BLX	231	50.2 \pm 0.3	51.6 \pm 0.1	51.9 \pm 0.3	49.6 \pm 0.3	50.0 \pm 0.3	60.1 \pm 0.4
<u>Flock</u>							
Control	133	48.5 \pm 0.4	49.6 \pm 0.4	49.9 \pm 0.4	47.8 \pm 0.4	48.2 \pm 0.4	57.9 \pm 0.5
Joined	271	46.4 \pm 0.3	47.3 \pm 0.3	48.3 \pm 0.3	46.2 \pm 0.3	46.4 \pm 0.3	57.6 \pm 0.4
<u>Year</u>							
1981	204	47.0 \pm 0.4	48.0 \pm 0.4	48.0 \pm 0.4	45.4 \pm 0.3	48.3 \pm 0.4	59.2 \pm 0.5
1982	200	47.9 \pm 0.4	49.5 \pm 0.4	50.2 \pm 0.4	48.5 \pm 0.4	46.3 \pm 0.4	56.3 \pm 0.5

Table 4.14 (continued).

Repeated-measurements analysis of variance

Source of variation	DF	Chi-square	Significance
Months	2	720.3	***
Breed	1	105.0	***
Flock	1	9.5	**
Year	1	8.4	**
Breed x flock	1	0.5	NS
Breed x year	1	5.3	*
Flock x year	1	0.8	NS
Months x breed	2	7.2	*
Months x flock	2	12.7	**
Months x year	2	130.7	***
Months x breed x flock	2	0.5	NS
Months x breed x year	2	2.3	NS
Months x flock x year	2	2.3	NS

Number of observations per month - 404

Figure 4-3 Live weights (kg) of 2-year-old ewes

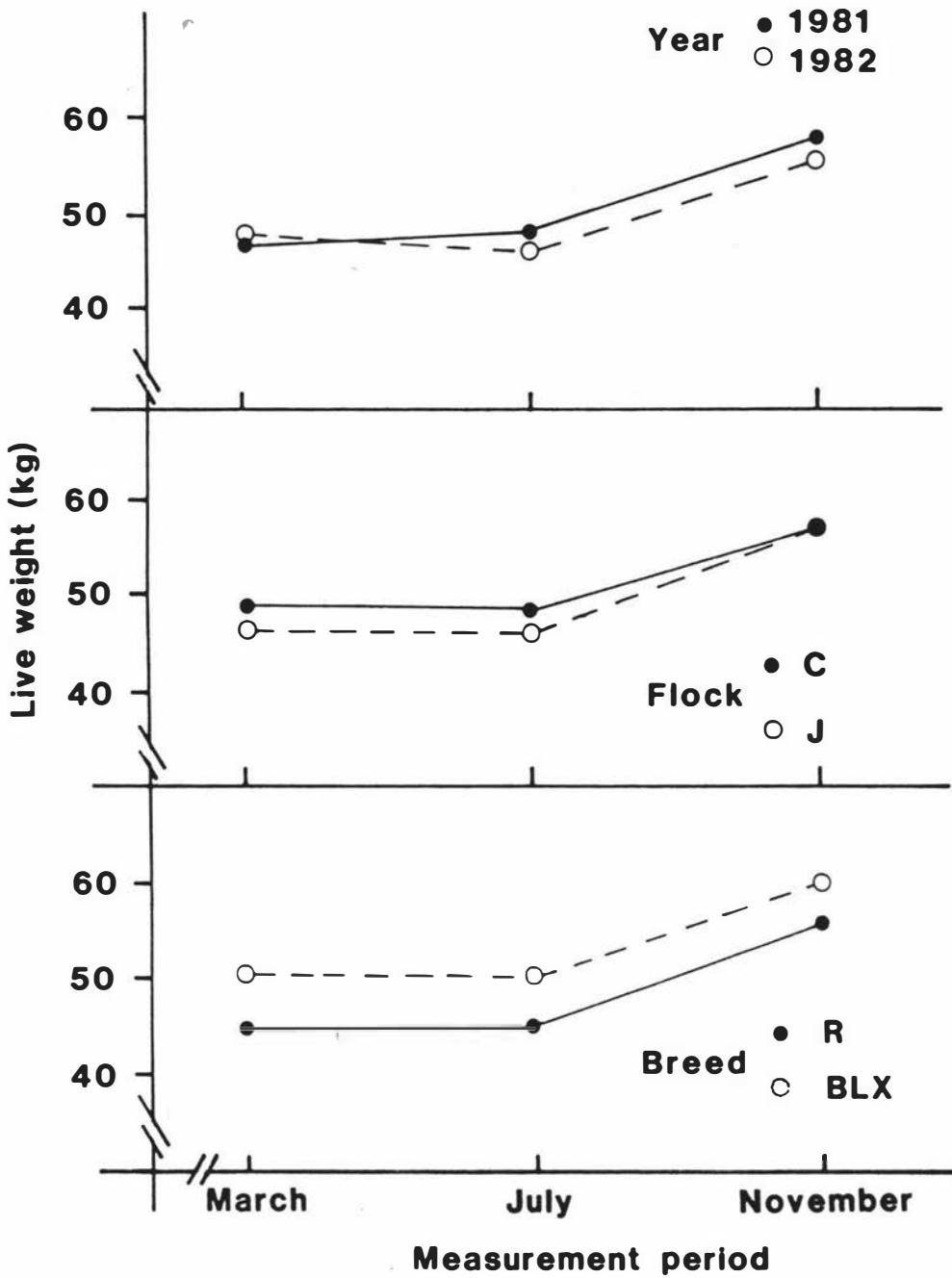


Table 4.15. Breed, year and group least squares means (and standard error) for the liveweights (kg) of 2-year-old ewes.

Classification	Number	March	April	May	June	July	November
Overall	404	47.5 ± 0.3	48.8 ± 0.3	49.2 ± 0.3	47.1 ± 0.3	47.4 ± 0.3	57.9 ± 0.4
<u>Breed</u>							
Romney	173	44.4 ± 0.4	45.6 ± 0.4	46.0 ± 0.4	44.1 ± 0.4	44.4 ± 0.4	55.2 ± 0.6
BLX	231	50.6 ± 0.4	52.0 ± 0.4	52.4 ± 0.4	50.0 ± 0.4	50.3 ± 0.4	60.5 ± 0.5
<u>Year</u>							
1981	204	46.6 ± 0.4	47.7 ± 0.4	47.7 ± 0.4	45.1 ± 0.4	48.0 ± 0.4	59.1 ± 0.5
1982	200	48.4 ± 0.4	50.0 ± 0.4	50.7 ± 0.4	49.0 ± 0.4	46.8 ± 0.4	56.6 ± 0.5
<u>Group</u>							
1. Weaned a lamb	115	43.8 ± 0.4B	45.6 ± 0.4	46.1 ± 0.4	44.2 ± 0.4	44.5 ± 0.4B	56.4 ± 0.6B
2. Control	119	48.7 ± 0.4DF	49.8 ± 0.4	50.0 ± 0.4	47.9 ± 0.4	48.4 ± 0.4AF	58.3 ± 0.6DF
3. Acyclic	67	47.6 ± 0.5E	49.1 ± 0.6	49.6 ± 0.6	47.3 ± 0.5	47.7 ± 0.6EH	58.4 ± 0.7CF
4. Mated not lambed	82	48.8 ± 0.5AF	50.0 ± 0.5	52.3 ± 0.5	47.9 ± 0.5	47.9 ± 0.5DFH	58.6 ± 0.7AF
5. Weaned no lamb	21	48.7 ± 1.0CF	49.6 ± 1.0	49.9 ± 1.1	48.0 ± 1.0	48.3 ± 1.1CF	57.6 ± 1.4E

Table 4.15 (continued).

Repeated-measurements analysis of variance

Source of variation	DF	Chi-square	Significance
Months	2	731.8	***
Breed	1	121.1	***
Year	1	0.7	NS
Group	4	53.0	***
Breed x year	1	4.2	*
Breed x group	4	7.0	NS
Year x group	4	4.9	NS
Months x breed	2	6.4	*
Months x year	2	166.9	***
Months x group	8	38.5	***
Months x breed x year	4	1.2	NS
Months x breed x group	8	4.3	NS
Months x year x group	8	2.8	NS

Number of observations per month - 404

Figure 4-4 Group levels Live weights (kg) . Liveweights of 2-year-old ewes

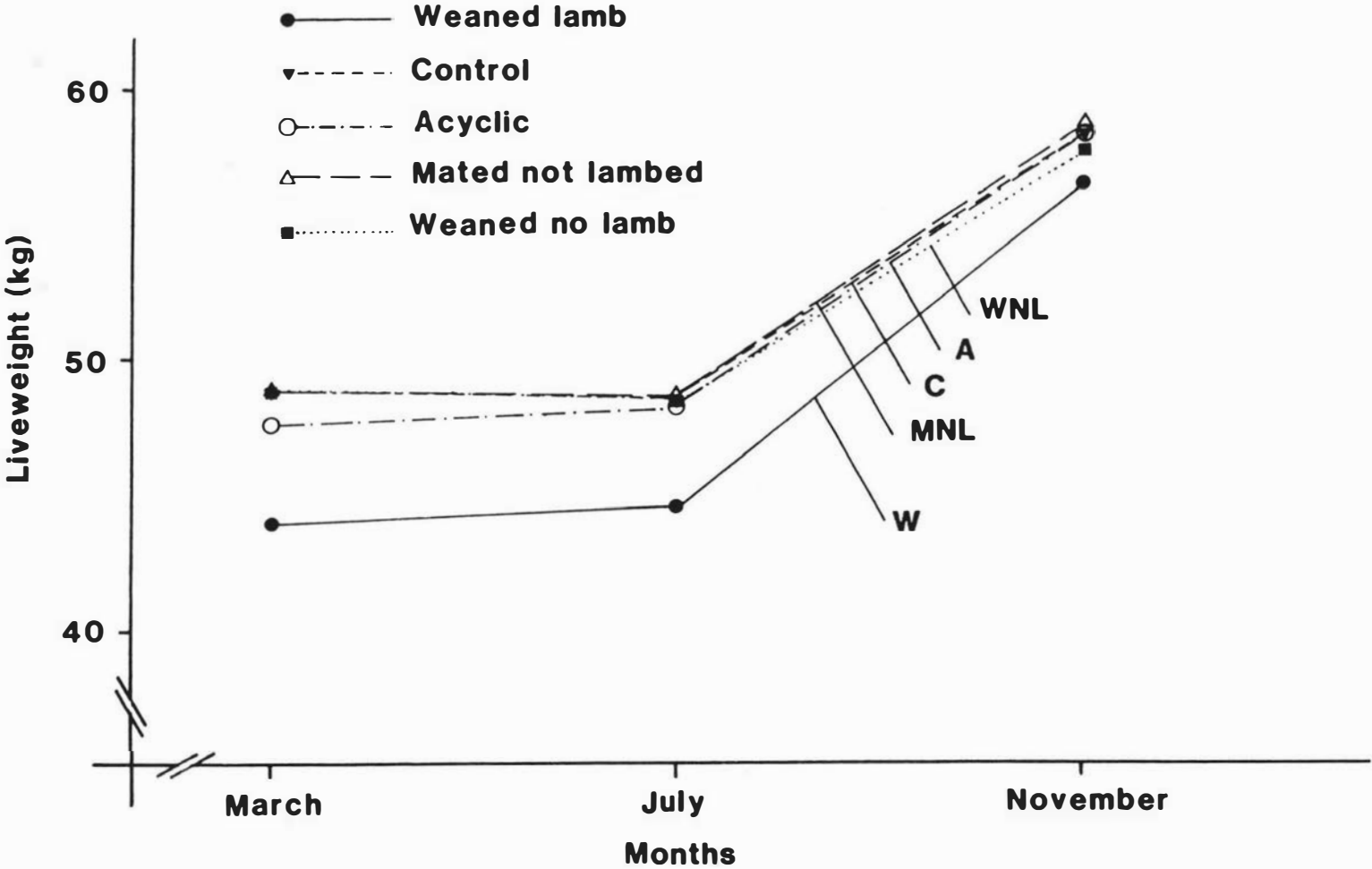


Table 4.16. Breed, flock and year least squares means (and standard error) for the weight gains (kg) of 2-year-old ewes.

Classification	Number	March-April	April-May	May-June	June-July	July-November
Overall	404	1.3 ± 0.1	0.3 ± 0.1	-2.1 ± 0.1	0.4 ± 0.1	10.4 ± 0.3
<u>Breed</u>						
Romney	173	1.2 ± 0.1	0.4 ± 0.1	-2.0 ± 0.1	0.3 ± 0.2	10.8 ± 0.4
BLX	231	1.4 ± 0.1	0.3 ± 0.1	-2.3 ± 0.1	0.4 ± 0.1	10.1 ± 0.3
<u>Flock</u>						
Control	133	1.1 ± 0.1	0.2 ± 0.2	-2.1 ± 0.2	0.5 ± 0.2	9.7 ± 0.5
Joined	271	1.5 ± 0.1	0.4 ± 0.1	-2.2 ± 0.1	0.3 ± 0.1	11.2 ± 0.3
<u>Year</u>						
1981	204	1.0 ± 0.1	-0.1 ± 0.1	-2.6 ± 0.1	2.9 ± 0.1	10.9 ± 0.4
1982	200	1.6 ± 0.1	0.7 ± 0.1	-1.7 ± 0.1	-2.2 ± 0.1	10.0 ± 0.4

Table 4.16 (continued).

Repeated-measurements analysis of variance			
Source of variation	DF	Chi-square	Significance
Months	4	768.8	***
Breed	1	6.2	*
Flock	1	12.6	***
Year	1	65.7	***
Breed x flock	1	0.5	NS
Breed x year	1	1.0	NS
Flock x year	1	2.1	NS
Months x breed	4	11.0	*
Months x flock	4	11.9	*
Months x year	4	437.8	***
Months x breed x flock	4	2.3	NS
Months x breed x year	4	15.8	**
Months x flock x year	4	7.1	NS

Number of observations per month - 404

Table 4.17. Breed, year and group least squares means (and standard error) for the liveweight gains (kg) of two-year-old ewes.

Classification	Number	March-April	April-May	May-June	June-July	July-November
Overall	404	1.29 \pm 0.1	0.37 \pm 0.1	-2.13 \pm 0.1	0.33 \pm 0.1	10.47 \pm 0.3
<u>Breed</u>						
Romney	173	1.22 \pm 0.2	0.34 \pm 0.2	-1.87 \pm 0.2	0.33 \pm 0.2	10.77 \pm 0.5
BLX	231	1.36 \pm 0.1	0.39 \pm 0.1	-2.39 \pm 0.1	0.33 \pm 0.2	10.17 \pm 0.4
<u>Year</u>						
1981	204	1.03 \pm 0.2	0.04 \pm 0.2	-2.64 \pm 0.2	2.90 \pm 0.2	11.11 \pm 0.5
1982	200	1.55 \pm 0.1	0.70 \pm 0.1	-1.62 \pm 0.2	-2.25 \pm 0.2	9.84 \pm 0.4
<u>Group</u>						
1. Weaned a lamb	115	1.74 \pm 0.2A	0.57 \pm 0.2A	-1.99 \pm 0.2A	0.39 \pm 0.2A	11.81 \pm 0.5A
2. Control	119	1.09 \pm 0.2CD	0.19 \pm 0.2A	-2.08 \pm 0.2A	0.52 \pm 0.2A	9.87 \pm 0.5E
3. Acyclic	67	1.49 \pm 0.2AD	0.58 \pm 0.2A	-2.36 \pm 0.2A	0.40 \pm 0.2A	10.70 \pm 0.6CF
4. Mated not lambed	82	1.24 \pm 0.2ADE	0.28 \pm 0.2A	-2.37 \pm 0.2A	0.03 \pm 0.2A	10.70 \pm 0.6DF
5. Weaned no lamb	21	0.90 \pm 0.4BE	0.23 \pm 0.4A	-1.85 \pm 0.4A	0.30 \pm 0.4A	9.27 \pm 1.2B

Table 4.17 (continued).

Repeated-measurements analysis of variance			
Source of variation	DF	Chi-square	Significance
Months	4	755.3	***
Breed	1	6.4	*
Year	1	66.8	***
Group	4	28.9	***
Breed x year	1	1.2	NS
Breed x group	4	3.0	NS
Year x group	4	2.1	NS
Months x breed	4	10.9	*
Months x year	4	432.6	***
Months x group	16	18.3	NS
Months x breed x year	4	15.6	**
Months x breed x group	16	14.0	NS
Months x year x group	16	12.0	NS

Number of observations per month - 404

Table 4.18. Effects of breed, flock, year and group on the incidence of oestrus in two-year-old ewes.

Classification	Number of ewes	Incidence of oestrus	
		First cycle (%)	All cycles (%)
Overall	411	73.2	99.3
<u>Breed</u>			
Romney	176	73.3	98.9
BLX	235	73.2	99.6
<u>Flock</u>			
Control	137	76.6	100
Joined	274	71.2	98.9
<u>Year</u>			
1981	207	86.5	99.6
1982	204	59.8	99.0
<u>Group</u>			
1. Weaned a lamb	116	69.0A	99.0 A
2. Control	121	76.0A	100.0 A
3. Acyclic	70	74.3A	97.1 A
4. Mated not lambed	83	74.7A	100.0 A
5. Weaned no lamb	21	71.4A	100.0 A

Analysis of Deviance

Source of variation	DF	Deviance	
		First cycle	All cycles
Breed	1	0.00 NS	0.70 NS
Flock	1	1.25 NS	2.29 NS
Year	1	38.78 ***	0.44 NS
Residual 1	407	437.46	32.08
Breed	1	0.00 NS	0.70 NS
Year	1	38.93 ***	0.47 NS
Group	4	1.39 NS	5.73 NS
Residual 2	404	437.17	28.60

1b.4 Conception: Table 4.19 shows the mean and the effects of breed, flock and year on conception for first service and all services based on the number of animals joined.

First service.

The only significant difference was between years ($P < 0.001$). Overall conception rate for first service was 72.1 per cent.

All services.

The overall conception rate for all services was 94.9 per cent. There was a significant breed effect ($P < 0.05$). A greater proportion of BLX ewes conceived compared to the Romneys. Difference between flocks showed that control ewes conceived more readily than joined but the difference was not significant.

Table 4.20 presents the analyses of data further examined to include the effects of breed, year and group (five levels) on conception to first service and all services.

The analyses showed only the year effect to be significant ($P < 0.001$). Between the five groups levels the conception for first service varied between groups but the differences were not significant. The conception rate overall was 71.5 per cent.

The analyses of all services showed that the breed difference was significant ($P < 0.05$) but that there were no significant differences between years and between groups. Conception for all services overall was 93.6 per cent.

1b.5 Day of birth: Table 4.21 presents the mean (\pm S.E.) for day of birth for the 2-year-old ewes and the analysis of the effects of breed, year and group.

The differences between breeds and between years were significant ($P < 0.05$) and ($P < 0.001$) respectively. There were no significant differences between groups.

1b.6 Incidence of multiple births in two-year-old ewes: Table 4.22 presents details on the incidence of multiple births and the associated

Table 4.19. Effects of breed, flock and year on conception rate to first service and to all services per ewe joined .

Classification	Number	Conception rate	
		First service	All services
Overall	411	72.1	94.9
<u>Breed</u>			
Romney	176	71.7	92.5
BLX	235	72.5	96.5
<u>Flock</u>			
Control	137	75.4	97.0
Joined	274	68.6	91.4
<u>Year</u>			
1981	207	82.4	92.8
1982	204	58.8	96.4

Source of Variation	Analysis of Deviance		
	DF	Deviance	
		<u>First service</u>	<u>All services</u>
Breed	1	0.29 NS	4.67 *
Flock	1	1.59 NS	3.45 NS
Year	1	30.06 ***	0.57 NS
Breed x flock	1	2.01 NS	0.04 NS
Breed x year	1	1.03 NS	0.02 NS
Flock x year	1	0.39 NS	1.07 NS
Residual	404	469.61	199.86

Table 4.20. Effects of breed, year and group on the conception rate to first service and all services per ewe joined.

Classification	Number	Conception rate	
		First service	All services
Overall	411	71.5	93.6
<u>Breed</u>			
Romney	176	69.2	91.5
BLX	235	73.6	95.4
<u>Year</u>			
1981	207	82.4	92.7
1982	204	57.3	94.3
<u>Group</u>			
1. Weaned a lamb	116	69.8 A	92.9A
2. Control	121	73.9A	96.6A
3. Acyclic	70	73.6A	93.4A
4. Mated not lambed	83	63.8A	89.1A
5. Weaned no lamb	21	75.4 A	95.0A

Source of variation	DF	Analysis of Deviance	
		Deviance	
		<u>First service</u>	<u>All services</u>
Breed	1	0.29 NS	4.67 *
Year	1	30.21 ***	0.51 NS
Group	4	2.76 NS	3.32 NS
Residual	404	471.72	201.18

Table 4.21. Effects of breed, year and group on the day of birth for two-year-old ewes.

Classification	Number Joined	Number lambing	Day of birth (mean \pm S.E.)
Overall	411	384	237 \pm 0.6
<u>Breed</u>			
Romney	176	159	238 \pm 0.9
BLX	235	225	237 \pm 0.8
<u>Year</u>			
1981	207	190	232 \pm 0.9
1982	204	194	243 \pm 0.8
<u>Group</u>			
1. Weaned a lamb	116	109	238 \pm 0.9
2. Control	121	116	237 \pm 0.9
3. Acyclic	70	66	237 \pm 1.2
4. Mated not lambed	83	73	239 \pm 1.1
5. Weaned no lamb	21	20	236 \pm 2.2

Source of Variation	Analysis of Variance	
	DF	Mean square
Breed	1	554.9 *
Year	1	10995.0 ***
Group	4	111.0 NS
Breed x year	1	74.6 NS
Breed x group	4	183.5 NS
Year x group	4	159.7 NS
Error	368	88.8
Total	383	

Table 4.22. Incidence of multiple births in two-year-old ewes.

Classification	Number	% ELT/EJ ^a
Overall	411	24
<u>Breed</u>		
Romney	176	16
BLX	235	29
<u>Flock</u>		
Control	137	23
Joined	274	24
<u>Year</u>		
1981	207	15
1982	204	32

Source of variation	Analysis of deviance	
	DF	Deviance
Breed	1	10.42 ***
Flock	1	0.35 NS
Year	1	15.31 ***
Breed x flock	1	0.57 NS
Breed x year	1	1.41 NS
Flock x year	1	0.71 NS
Residual	404	420.94

a: ELT/EJ = Ewes Lambled Twins per Ewe Joined.

analysis of the effects of breed, flock and year.

There was a significant effect of breed ($P < 0.001$), the BLX animals having the highest twinning rate. The analysis also showed that the effect of the year was significant ($P < 0.001$).

1b.7 Weaning percentage: The distribution of ewes and the number of lambs weaned according to breed, flock and year is presented in Table 4.23.

Two-year-old ewes weaning no lamb.

The analysis of the data showed that there was a significant breed effect ($P < 0.01$), less Romney than BLX ewes weaning a lamb. There was a significant difference between years ($P < 0.05$). The flock effect was small.

Two-year-old ewes weaning one lamb.

Examination of the results showed that neither of the factors studied was significant, and 65% of the ewes weaned one lamb.

Two-year-old ewes weaning twin lambs.

The difference between years was significant ($P < 0.001$). The BLX animals weaned 6% more twins than the Romneys, but the difference was not significant.

Two-year-old ewes weaning lamb(s).

Lambs weaned per ewe joined overall was 97%. The breed effect was significant ($P < 0.01$), the BLX ewes weaning 16% more lambs than the Romneys. The year effect was significant ($P < 0.05$), but the flock difference was small.

1b.8 Fleece production: Table 4.24 contains sub-class means and the analysis of the factors causing variation in fleece weight.

The mean fleece weights for February and December were 2.46 kg and 3.13 kg respectively. There were significant differences between breeds ($P < 0.001$) and between years ($P < 0.001$) for both February and December fleece weights. A significant breed-by-year ($P < 0.001$) interaction arose in the analysis of February fleece weights.

The mean fleece weights were examined further to include the effects of breed, year and group. Means and the analyses associated are presented in Table 4.25.

Fitting the second model to February fleece weights showed that there were significant effects for breed ($P<0.001$), year ($P<0.001$), group ($P<0.001$), breed-by-year interaction ($P<0.001$) and also a significant breed-by-group interaction ($P<0.05$).

Fitting the same model for December fleece weights showed that there were significant effects for breed ($P<0.001$) and year ($P<0.001$). The group effect was not significant. Between groups animals which lambed as hoggets had lower fleece weights than the control animals, but the difference was not significant.

Cumulative fleece weights.

The mean fleece weights for the combined February and December shears and the analyses of factors causing variation are presented in Table 4.26.

There were significant differences between breeds ($P<0.001$), years ($P<0.01$) and groups ($P<0.05$). Also, there were significant breed-by-year interaction ($P<0.05$) and breed-by-group interaction ($P<0.05$). Between groups the two-year-old ewes which lambed as hoggets had the lowest fleece weights compared to the other groups, but the difference was not significant.

Table 4.23. Distribution of two-year-old ewes relative to number of lambs weaned.

Classification	Number	Weaned (%)			
		<u>Zero lamb</u>	<u>One lamb</u>	<u>Two lambs</u>	<u>LW/EJ^a</u>
Overall	411	19	65	16	97
<u>Breed</u>					
Romney	176	25	63	13	88
BLX	235	14	67	19	104
<u>Flock</u>					
Control	137	18	66	17	99
Joined	274	20	65	16	96
<u>Year</u>					
1981	207	24	67	9	86
1982	204	14	63	23	100

a: Lamb Weaned per Ewe Joined.

Analysis of deviance					
Source of variation	DF	Deviance			
		<u>Zero</u>	<u>One</u>	<u>Two</u>	<u>LW/EJ^a</u>
Breed	1	7.19 **	0.81 NS	2.95 NS	7.19 **
Flock	1	0.11	0.02 NS	0.02 NS	0.11 NS
Year	1	4.92 *	1.07 NS	13.95 ***	4.92 *
Breed x flock	1	0.44 NS	0.67 NS	0.08 NS	0.44 NS
Breed x year	1	1.65 NS	0.14 NS	2.25 NS	0.01 NS
Flock x year	1	1.65 NS	0.40 NS	0.39 NS	1.66 NS
Residual	404	385.08	529.26	342.55	385.08

a: Lamb weaned per Ewe Joined

Table 4.24. Effects of breed, flock and year on February and December mean fleece weights (kg) for two-year-old ewes.

Classification	<u>February</u>		<u>December</u>	
	Number	Fleece weight	Number	Fleece weight
Overall	411	2.46 \pm 0.02	402	3.13 \pm 0.02
<u>Breed</u>				
Romney	173	2.41 \pm 0.03	172	3.05 \pm 0.04
BLX	238	2.50 \pm 0.02	230	3.20 \pm 0.03
<u>Flock</u>				
Control	137	2.48 \pm 0.03	131	3.14 \pm 0.04
Joined	274	2.43 \pm 0.02	271	3.12 \pm 0.03
<u>Year</u>				
1981	208	2.40 \pm 0.02	203	3.29 \pm 0.03
1982	203	2.51 \pm 0.03	199	2.97 \pm 0.03

Analysis of Variance

Source of variation	<u>February</u>		<u>December</u>	
	DF	Mean square	DF	Mean square
Breed	1	1.51 ***	1	2.40 ***
Flock	1	0.15 NS	1	0.00 NS
Year	1	1.32 ***	1	9.98 ***
Breed x flock	1	0.27 NS	1	0.45 NS
Breed x year	1	1.28 ***	1	0.10 NS
Flock x year	1	0.16 NS	1	0.06 NS
Error	404	0.10	395	0.18
Total	410		401	

Table 4.25. Effects of breed, year and group on February and December mean fleece weights (kg) for two-year-old ewes.

Classification	<u>February</u>		<u>December</u>	
	Number	Fleece weight	Number	Fleece weight
Overall	411	2.44 \pm 0.02	402	3.11 \pm 0.03
<u>Breed</u>				
Romney	173	2.35 \pm 0.03	172	3.00 \pm 0.04
BLX	238	2.52 \pm 0.03	230	3.23 \pm 0.04
<u>Year</u>				
1981	208	2.37 \pm 0.03	203	3.25 \pm 0.04
1982	203	2.51 \pm 0.03	199	2.98 \pm 0.04
<u>Group</u>				
1. Weaned a lamb	114	2.32 \pm 0.03A	114	3.11 \pm 0.04A
2. Control	121	2.50 \pm 0.03C	117	3.18 \pm 0.04A
3. Acyclic	69	2.46 \pm 0.04 BC	66	3.13 \pm 0.05A
4. Mated not lambed	87	2.56 \pm 0.03 DC	84	3.14 \pm 0.05A
5. Weaned no lamb	20	2.37 \pm 0.07A	21	3.01 \pm 0.10A

Analysis of variance

Source of variation	<u>February</u>		<u>December</u>	
	DF	Mean square	DF	Mean square
Breed	1	1.51 ***	1	2.36 ***
Year	1	1.30 ***	1	9.00 ***
Group	4	0.77 ***	4	0.07 NS
Breed x year	1	1.20 ***	1	0.10 NS
Breed x group	4	0.23 *	4	0.40 NS
Year x group	4	0.16 NS	4	0.06 NS
Error	395	0.09	386	0.18
Total	410		401	

Table 4.26. Effects of breed, year and group on the cumulative fleece weights (kg), February and December, for two-year-old ewes.

Classification	Number	Cumulative fleeceweights
		(mean \pm S.E.)
Overall	400	5.54 \pm 0.04
<u>Breed</u>		
Romney	171	5.34 \pm 0.06
BLX	229	5.75 \pm 0.05
<u>Year</u>		
1981	203	5.62 \pm 0.06
1982	197	5.47 \pm 0.06
<u>Group</u>		
1. Weaned a lamb	113	5.43 \pm 0.06A
2. Control	117	5.68 \pm 0.06B
3. Acyclic	66	5.57 \pm 0.08AB
4. Mated not lambed	84	5.69 \pm 0.07B
5. Weaned no lamb	20	5.34 \pm 0.15A

Source of variation	Analysis of variance	
	DF	Mean square
Breed	1	7.51 ***
Year	1	3.51 **
Group	4	1.09 *
Breed x year	1	1.92 *
Breed x group	4	1.18 *
Year x group	4	0.33 NS
Error	384	0.39
Total	399	

2. LAMBING BEHAVIOUR AND ASSOCIATED OBSERVATIONS

2.1 Pre-partum behaviour

Several behavioural patterns were observed during the pre-parturient period. These behavioural traits were described as:

Restlessness - various postural changes that involved lying down, standing up, walking for a few metres and then turning around.

Walking - the animal walked in small circles.

Seeking - the animal appeared to be searching for something.

Vocalizing - loud calling or bleating.

Licking - the fore limbs and especially near the feet were licked.

Pawing - striking the ground with one of the front feet.

Maternal interest - the animal showed interest in alien lambs before giving birth herself.

An individual animal usually showed some, but not necessarily all of these behavioural characteristics.

Table 4.27 shows the incidence of the various behaviour characteristics in the hoggets. Restlessness was seen in 85% of the animals before birth and it was the most common trait. Normal periods of restlessness were noticed to occur in some cases as early as 2-3 h before birth, but in others it was only evident within a short time before parturition (down to 4 minutes pre-partum).

Several traits (walking, seeking, vocalizing and pawing) were each recorded in about 50% of the animals studied. Licking behaviour was noticed only to a minor extent.

Table 4.28 shows the incidence of behaviour characteristics in the two-year-old ewes. Restlessness was the most common behaviour recorded for the animals, while licking was also noticed to a minor extent.

Table 4.27. Pre-partum behaviour characteristics of ewe hoggets.

Classification	No. of animals	<u>Incidence of behaviour characteristics (%)</u>						Pre-maternal interest
		Restlessness	Walking	Seeking	Vocalizing	Licking	Pawing	
Overall	52	85	69	50	50	2	40	27
<u>Breed</u>								
Romney	18	89	56	44	67	0	50	22
BLX	34	82	57	53	41	3	35	29
<u>Year</u>								
1979	25	92	64	44	52	0	32	36
1980	27	78	74	56	48	4	48	19

Table 4.27 (cont.)

Analysis of deviance †

Source of variation	DF	<u>Deviance</u>			Pre-maternal interest
		Restlessness	Walking	Pawing	
Breed	1	0.40 NS	2.36 NS	1.05 NS	0.32 NS
Year	1	2.07 NS	0.58 NS	1.52 NS	2.09 NS
Residual	49	42.17	61.25	67.58	58.17

† - traits analysed separately.

Table 4.28. Pre-partum behaviour characteristics of two-year-old ewes.

Classification	No. of ewes	<u>Incidence of behaviour characteristics (%)</u>						Pre-maternal interest
		Restlessness	Walking	Seeking	Vocalizing	Licking	Pawing	
Overall	113	76	62	40	60	7	68	36
<u>Breed</u>								
Romney	44	80	68	39	59	7	82	34
BLX	69	74	58	39	61	7	59	38
<u>Lamb rank</u>								
Single	77	77	69	36	71	6	73	38
Twin	36	75	47	44	36	8	58	33
<u>Year</u>								
1981	47	72	70	43	66	4	45	47
1982	66	79	56	36	56	9	85	29
<u>Flock †</u>								
Flock 1	77	69	64	38	57	6	66	38
Flock 2	36	92	58	42	67	8	72	33

† Flock 1: Two-year-old ewes that lambed for the first time (primiparturient);
 Flock 2: Two-year-old ewes that lambed as hoggets (multiparturient).

Table 4.28 (cont.)

Analysis of deviance †

Source of Variation	DF	<u>Deviance</u>							pre-maternal interest
		Restlessness	Walking	Seeking	Vocalizing	Licking	Pawing		
Breed	1	0.48 NS	1.20 NS	0.00 NS	0.04 NS	0.01 NS	6.52 *	0.15 NS	
Lamb rank	1	0.01 NS	4.33 *	0.67 NS	13.10 ***	0.12 NS	1.58 NS	0.25 NS	
Year	1	0.78 NS	1.11 NS	0.78 NS	0.08 NS	0.92 NS	30.47 ***	3.72 NS	
Flock	1	7.68 **	0.22 NS	0.21 NS	1.38 NS	0.08 NS	0.04 NS	0.08 NS	
Residual	108	115.32	143.27	149.42	137.34	56.66	102.82	143.84	

† Traits analysed separately.

Physical signs of impending parturition

Two of the physical signs of impending parturition were recorded for the animals. These were:

- (a) Protrusion of the amniotic sac - seen as a fluid-filled sac protruding from the vagina. The sac sometimes was dark red in colour, but often had a watery appearance. The time was recorded.
- (b) Discharge of fluid - the amniotic sac eventually ruptured and spilled its contained fluid. The time was noted.

Either of these signs were recorded for each animal as shown in Tables 4.29 and 4.30 for hoggets and 2-year-old ewes respectively.

These physical signs were first seen from about 4 h to 4 min prior to a normal lambing in all animals.

Table 4.29. Incidence of signs of impending parturition in ewe hoggets.

Classification	Number	% of animals showing:	
		Fluid discharge	Protrusion of amniotic sac
Overall	52	50	50
<u>Breed</u>			
Romney	18	61	39
BLX	34	44	56
<u>Year</u>			
1979	25	52	48
1980	27	48	52

Table 4.30. Incidence of signs of impending parturition in two-year-old ewes.

Classification	Number	% of animals showing:	
		Fluids discharge	Protrusion of amniotic sac
Overall	113	65	35
<u>Breed</u>			
Romney	44	68	32
BLX	69	62	38
<u>Lamb rank</u>			
Single	77	70	31
Twin	36	53	47
<u>Year</u>			
1981	47	70	30
1982	66	61	39
<u>Flock †</u>			
Flock 1	77	71	29
Flock 2	36	50	50

Source of variation	Analysis of deviance	
	DF	Deviance
Breed	1	0.41 NS
Lamb rank	1	2.96 NS
Year	1	0.43 NS
Flock	1	4.73 *
Residual	108	138.34

† Flock 1 - Primiparturient ewes
 Flock 2 - Multiparturient ewes.

2.2 Behaviour during parturition

Most animals chose to lamb in areas near the corner of the paddock or along the boundary fences. Several behavioural patterns were noticed during this period, some of which were described earlier. Other traits were described as:

Isolation - the relative separation of the animal near the time of parturition from the rest of the flock.

Distress calls - calls of pain during parturition.

Table 4.31 presents the incidence of different behaviour traits in the hoggets.

The most common traits observed were lying, walking and standing up. Several other characteristics, isolation, distress calls and pawing were noticed in about 58%, 69% and 39% of the animals studied, respectively.

Table 4.32 shows the percentage of several behavioural patterns during parturition classified according to breed, lamb rank, year and flock in two-year-old ewes. These behaviours were seen in about 81% of the animals observed.

Animals generally gave birth in a recumbent position, and on three occasions hoggets gave birth while they were standing. Birth took place where fluids spilled, and on many occasions the animals were seen licking that area. Only a few times were hoggets seen moving away from that area, and it was considered that might have been due to difficulties during lambing.

Similar behaviour was observed for two-year-old ewes. Generally, the animals showed more restlessness and periods of lying down with abdominal straining. As the straining became more frequent it was sometimes associated with distress calls.

The foetal membranes then ruptured and the foetal fluids were lost; after this the ewe continued straining more strongly and frequently until the lamb was born.

Table 4.31. General behaviour of the ewe hoggets during lambing.

Classification	Number	Isolation	<u>Incidence of behaviour characteristics (%)</u>				
			Lying	Walking	Distress calls	Standing up	Pawing
Overall	52	58	96	85	69	87	39
<u>Breed</u>							
Romney	18	61	100	89	83	78	50
BLX	34	56	94	82	62	91	32
<u>Year</u>							
1979	25	84	96	76	52	72	28
1980	27	33	96	96	68	100	48

Table 4.31 (cont.)

Source of Variation	DF	Analysis of Deviance †					
		Isolation	Lying	Walking	Distress calls	Standing up	Pawing
Breed	1	0.13 NS	1.74 NS	0.40 NS	2.74 NS	1.72 NS	1.53 NS
Year	1	14.46 ***	0.01 NS	2.92 NS	7.61 **	11.52 ***	2.44 NS
Residual	49	56.26	15.21	41.32	53.85	27.82	65.32

† - traits analysed separately.

Table 4.32. General behaviour of the two-year-old ewes during lambing.

Classification	Number	Isolation	Incidence of behaviour characteristics (%)					
			Lying	Walking	Distress calls	Standing up	Vocalizing	Pawing
Overall	113	81	92	64	86	96	72	79
<u>Breed</u>								
Romney	44	80	91	68	91	95	75	86
BLX	69	83	93	61	83	96	70	74
<u>Lamb rank</u>								
Single	77	82	94	73	91	97	77	83
Twin	36	81	89	44	75	92	61	69
<u>Year</u>								
1981	47	77	96	96	87	100	72	62
1982	66	85	89	41	85	92	71	91
<u>Flock †</u>								
Flock 1	77	81	92	66	86	97	75	75
Flock 2	36	83	92	58	86	92	64	83

† Flock 1 - Primiparturient ewes
 Flock 2 - Multiparturient ewes.

Table 4.32 (cont.)

Source of variation	DF	Analysis of deviance †						
		Isolation	Lying	Walking	Distress calls	Standing up	Vocalizing	Pawing
Breed	1	0.16 NS	0.12 NS	0.63 NS	1.60 NS	0.00 NS	0.39 NS	2.61 NS
Lamb rank	1	0.04 NS	0.76 NS	7.93 **	4.23 *	1.80 NS	2.62 NS	2.12 NS
Year	1	1.36 NS	1.27 NS	37.04 ***	0.03 NS	4.58 *	0.08 NS	20.48 ***
Flock	1	0.09 NS	0.00 NS	0.16 NS	0.00 NS	1.34 NS	1.63 NS	1.09 NS
Residual	108	106.86	60.64	102.28	86.30	33.23	129.96	90.57

† Traits analysed separately.

Presentation of the lamb

Observations were made on the presentation of the lambs for birth. Normal presentation implies that the fore-hooves and the muzzle appears first through the vulva. Abnormal presentations that differed from the above included:

Head appearing alone at the vulva - 70% of abnormal.

Head and one fore-limb appearing at the vulva - 30%.

Table 4.33 shows the percentage of hoggets which had different presentations to the normal. Most hoggets lambed normally, but on 6 occasions, assistance was given to the hoggets. In 2 of these cases, the lamb's head presented first through the birth canal, and the lamb subsequently died during birth.

Table 4.34 shows the percentage of abnormal presentation for two-year-old ewes classified according to breed, lamb rank, year and flock.

Overall abnormal presentations were 14%. The types of abnormal presentation observed included:

Head alone at vulva - 81% of abnormal.

Head and one fore-limb - 13%.

Upside-down presentation was observed in 6% of the abnormal deliveries.

Table 4.33. Incidence of abnormal presentation of lambs from hoggets.

Classification	Number	% Abnormal delivery
Overall	52	19
<u>Breed</u>		
Romney	18	28
BLX	34	32
<u>Year</u>		
1979	25	20
1980	27	19

Source of variation	Analysis of deviance	
	DF	Deviance
Breed	1	1.25 NS
Year	1	0.01 NS
Residual	49	49.65

Table 3.34. Incidence of abnormal presentation of lambs from two-year-old ewes.

Classification	Number	% Abnormal delivery
Overall	113	14
<u>Breed</u>		
Romney	44	14
BLX	69	14
<u>Lamb rank</u>		
Single	77	18
Twin	36	6
<u>Year</u>		
1981	47	17
1982	66	12
<u>Flock †</u>		
Flock 1	77	16
Flock 2	36	11

Source of variation	Analysis of deviance	
	DF	Deviance
Breed	1	0.02 NS
Lamb rank	1	3.81 NS
Year	1	0.12 NS
Flock	1	0.36 NS
Residual	108	87.87

† Flock 1 - Primiparturient ewes
 Flock 2 - Multiparturient ewes.

2.3 Post-partum behaviour

The majority of hoggets and 2-year-old ewes were on their feet within 5 min after giving birth. Figure 4.5 presents the time and percentage of hoggets and 2-year-old ewes lying after parturition. Those animals which took a longer time to get up were noticed to have had a long labour period associated with difficulties during birth. Few animals from both age groups took more than 20 min to get up on their feet.

After delivery of the lamb(s), most animals showed similar patterns of behaviour. Most animals stood on their feet within the first few minutes, turned towards the newborn and started grooming it. Grooming on most occasions was seen to start at the head and then the body, legs and tail were licked on several occasions. It was also noticed that if membranes covered the body and head of the lamb then they were eaten by both hoggets and the 2-year-old ewes after grooming started. The mother often moved when the lambs first tried to approach the udder, so as to keep the lamb in front of her head to facilitate grooming. On some occasions the mother would assist the lamb to find the teat and the udder area by arching her back and moving her hind leg out of the way. The teats seemed to be found by trial and error.

2.4 Time of parturition

The distribution of lambing time during the daylight for hoggets and 2-year-old ewes is shown in Table 4.35 and Figure 4.6.

There was an obvious trend in the incidence of time of parturition. The highest proportion of births occurred between 1.00 h and 14.00 h for both hoggets and 2-year-old ewes. The lowest incidence of births (23% and 19%) was between 07.00 h and 11.00 h for both ages of animals. The time of lambing for both hoggets and 2-year-old ewes in each hour period showed no consistent trend.

Figure 4-5 Interval from birth to standing for hoggets and 2-year-old ewes (min)

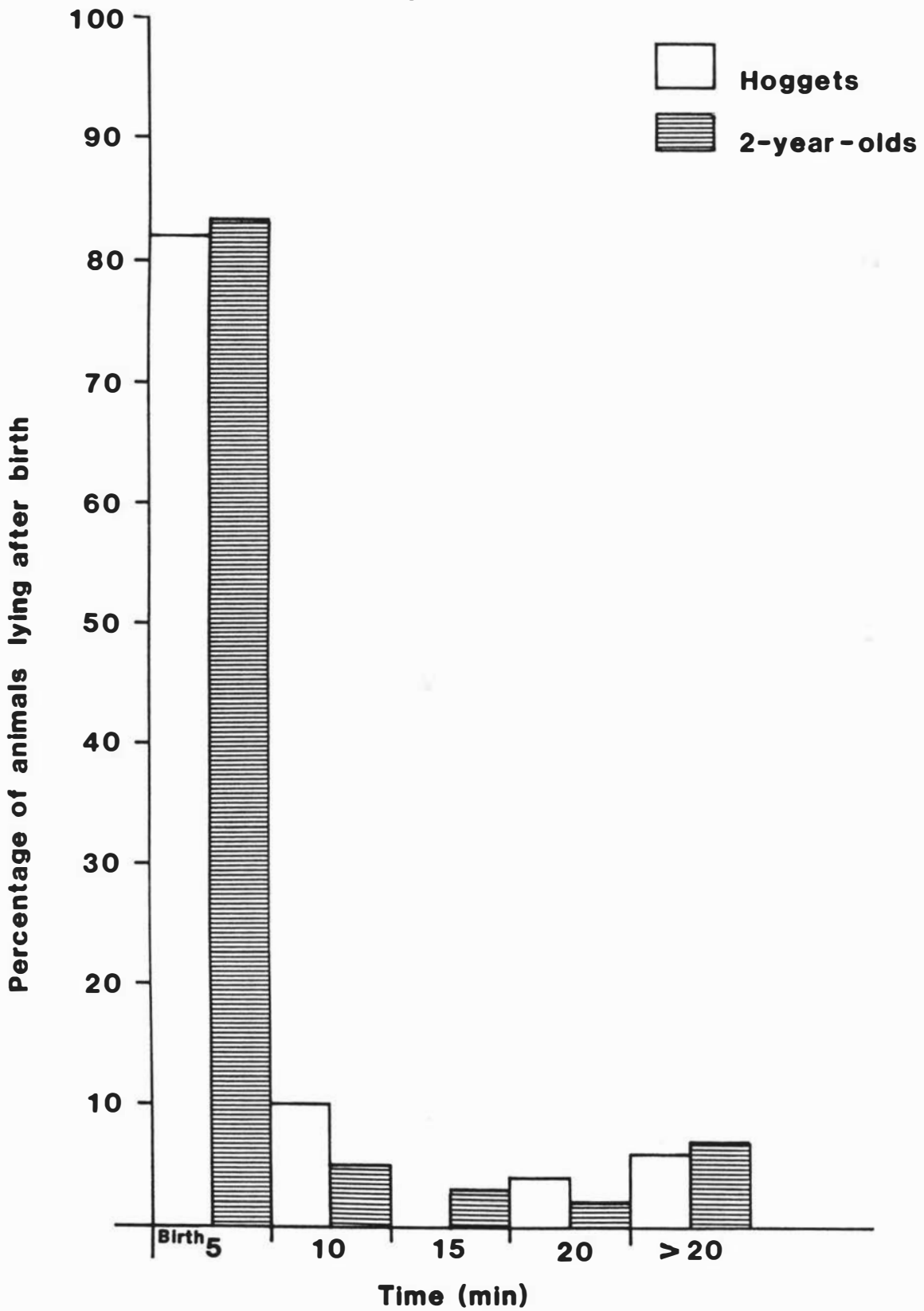
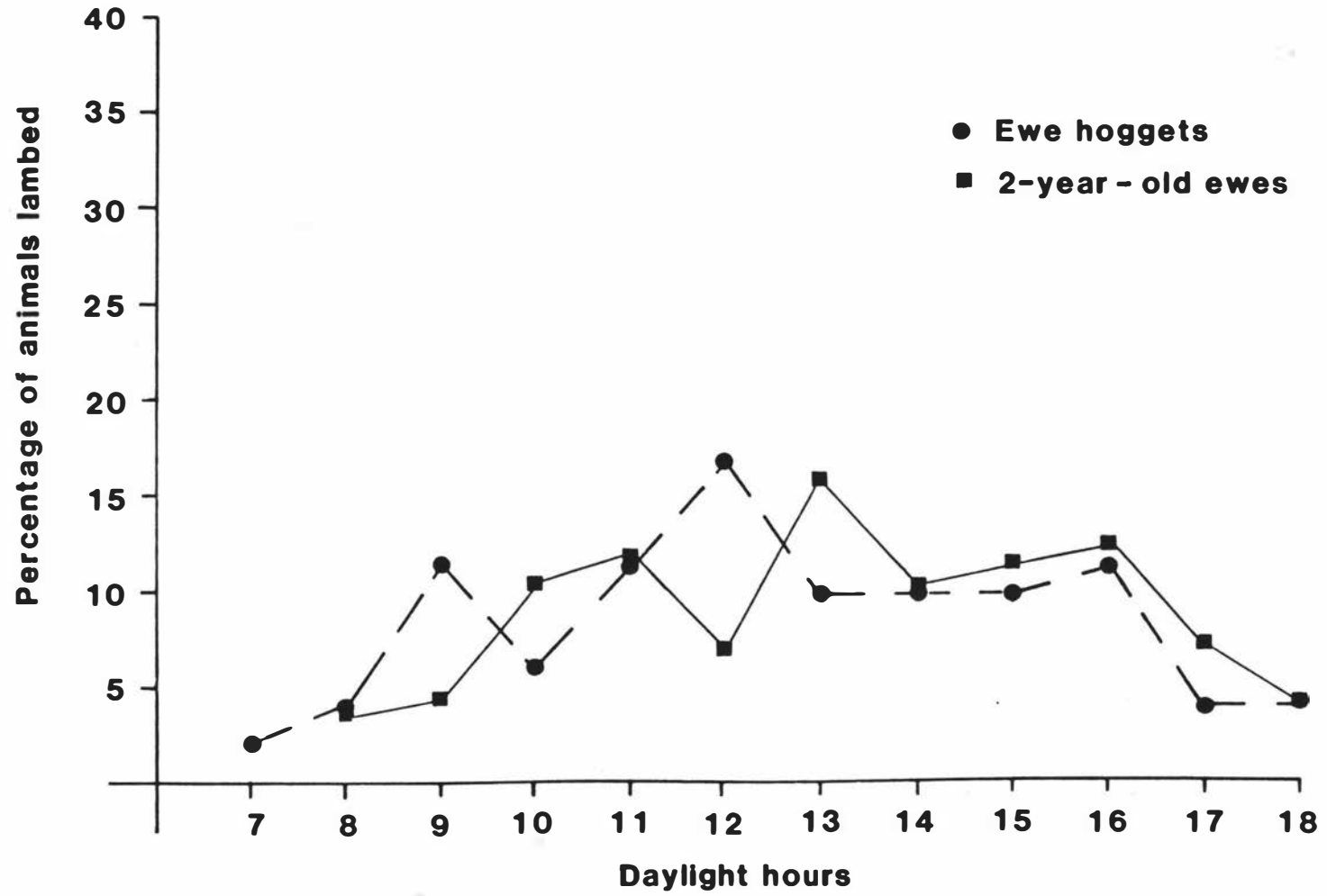


Table 4.35. Time of parturition recorded in daylight for hoggets and two-year-old ewes.

Intervals	Hoggets		Two-year-old ewes	
	Number	%	Number	%
07.00 h - 11.00 h	12	23	21	19
11.00 h - 14.00 h	25	48	52	46
14.00 h - 18.00 h	15	29	40	35
Total	52	100	113	100

Figure 4-6 Time of lambing



2.5 Length of labour

In this study length of labour is defined as the time from rupture of the amniotic sac until the delivery of the lamb(s).

Table 4.36 shows the length of labour in the hoggets classified according to breed, lamb rank and year. Overall the mean length of labour was 42 min (range, 4-190 min). The analysis of data showed that breed and lamb rank had no significant effect on length of labour; there was a significant difference between years ($P < 0.05$).

Figure 4.7 shows within each breed group, the distribution of hoggets classified for length of labour. Considering both breed groups, the percentage of hoggets relative to the intervals of labour up to 30 min were 46%; 31-60 min, 30%; 61-90 min, 16%; and 91-190 min, 5%. In the 9 hoggets that produced twins the length of labour was usually shorter for the second member of each twin-set.

The correlation coefficient between birth weight and length of labour was significant ($r = 0.54$; $P < 0.001$).

Table 4.37 presents the interval length of labour for 2-year-old ewes which gave birth without assistance. Overall the mean of labour was about 69 min (range 6-253 min). Results revealed by the analysis showed that there were no significant differences between breeds nor between flocks. The effect of lamb rank was significant ($P < 0.05$) and difference due to the effect of the year were found to be significant ($P < 0.05$). Figure 4.7 shows the distribution of 2-year-old animals classified for length of labour within each breed group. The percentage of 2-year-old ewes relative to the intervals of labour were 27% up to 30 min; 31%, 30-60 min; 15%, 61-90 min; and 27%, 90-253 min.

A similar analysis was carried out on the length of labour for the animals that gave birth to twins, and the effect of lamb numbers was studied. Results obtained are presented in Table 4.38. Examination of the results clearly indicates that length of labour for the second-born lambs was significantly shorter than for the first-born lambs of the twins ($P < 0.001$).

Table 4.36. Effects of breed, lamb rank and year on the length of labour (min) in ewe hoggets.

Classification	Number	Length of labour
Overall	47	41.9 \pm 6.7
<u>Breed</u>		
Romney	15	42.8 \pm 10.7
BLX	32	41.0 \pm 7.7
<u>Lamb rank</u>		
Single	38	41.2 \pm 5.7
Twin	9	42.6 \pm 12.8
<u>Year</u>		
1979	23	33.6 \pm 10.5
1980	24	50.3 \pm 8.3

Source of variation	Analysis of variance	
	DF	Mean square
Breed	1	0.01 NS
Lamb rank	1	0.00 NS
Year	1	0.43 *
Breed x lamb rank	1	0.07 NS
Breed x year	1	0.04 NS
Lamb rank x year	1	0.09 NS
Error	40	0.09
Total	46	

Figure 4-7 Length of labour

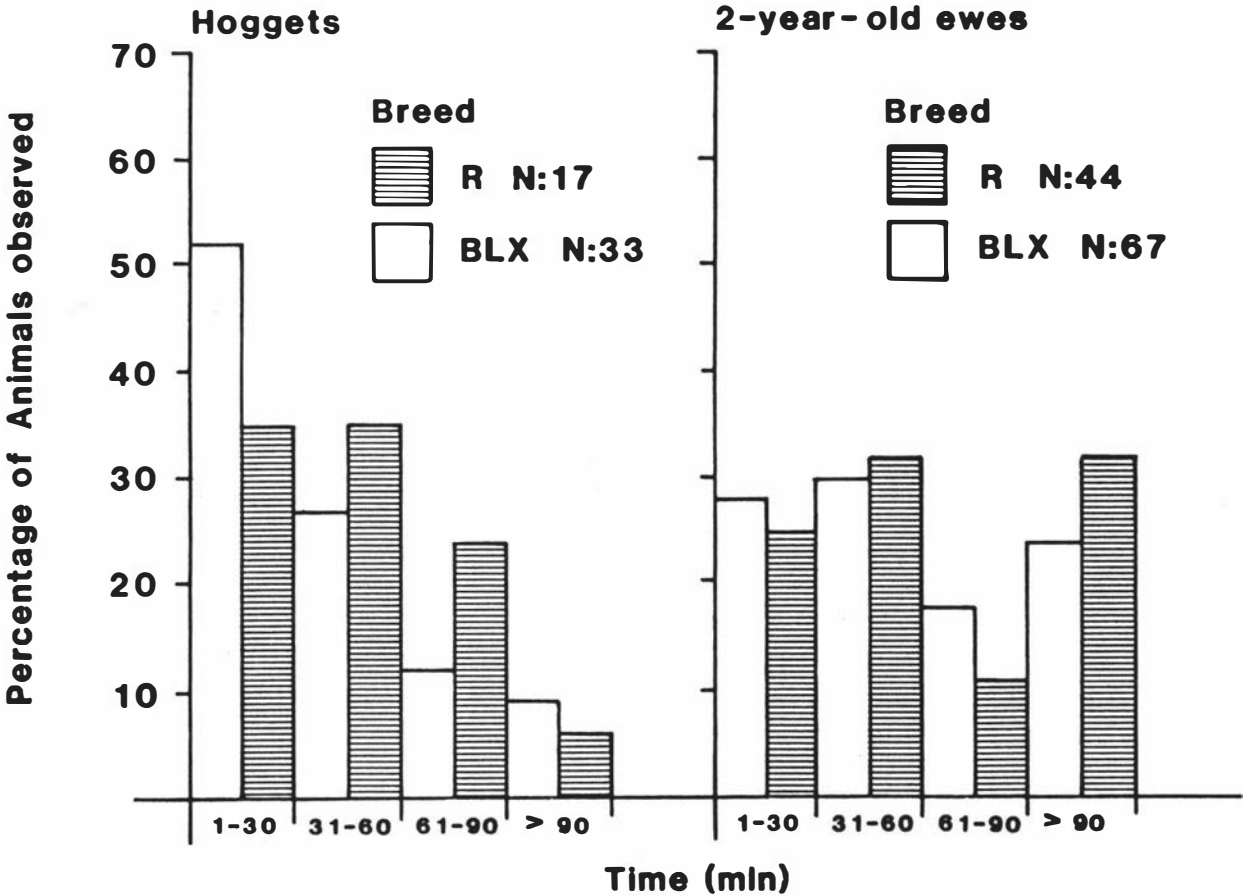


Table 4.37. Effects of flock, breed, lamb rank and year on the length of labour (min) in two-year-old ewes.

Classification	Number	Length of labour
Overall	101	69.2 \pm 7.7
<u>Flock</u> †		
Flock 1	67	52.0 \pm 10.5
Flock 2	34	60.6 \pm 6.7
<u>Breed</u>		
Romney	40	68.4 \pm 12.7
BLX	61	70.0 \pm 8.2
<u>Lamb rank</u>		
Single	68	79.7 \pm 7.7
Twin	33	58.7 \pm 13.4
<u>Year</u>		
1981	42	80.3 \pm 11.8
1982	59	58.1 \pm 9.0

Source of variation	Analysis of variance	
	DF	Mean square
Flock	1	0.32 NS
Breed	1	0.02 NS
Lamb rank	1	0.52 *
Year	1	0.48 *
Flock x breed	1	0.06 NS
Flock x lamb rank	1	0.08 NS
Flock x year	1	0.00 NS
Breed x lamb rank	1	0.00 NS
Breed x year	1	0.09 NS
Lamb rank x year	1	0.03 NS
Error	90	0.11
Total	100	

† Flock 1 - Primiparturient ewes
Flock 2 - Multiparturient ewes.

Table 4.38. Effect of lamb number on the length of labour in ewes giving birth to twins.

Classification	Number	Length of labour (min)
First lamb	33	48.3 \pm 4.9
Second lamb	33	16.0 \pm 4.9

Analysis of variance		
Source of variation	DF	Mean square
Lamb number	1	6.1 ***
Error	64	0.2
Total	65	

Length of labour for the single lambs was found to be correlated significantly with birth weight ($r = 0.38$, $P < 0.05$), while this correlation was not significant for the twins ($r = 0.29$).

Time between twin deliveries

The average interval between the birth of the first and second lambs of a twin-pair was recorded for hoggets and 2-year-old ewes. Few hoggets gave birth to twins and the overall mean was about 17 min (range, 0-46 min).

Table 4.39 shows the effect of breed, year and flock on the time between twin deliveries for 2-year-old ewes. The overall mean interval was about 12 min. There was a significant effect due to the year ($P < 0.05$) but the effects of breed and flock were not significant.

Table 4.39. The mean interval between the delivery of members of a twin pair (two-year-old ewes).

Classification	Number of ewes	Mean time (min)
Overall	34	11.7 \pm 3.9
<u>Breed</u>		
Romney	10	8.7 \pm 6.0
BLX	24	14.6 \pm 3.7
<u>Year</u>		
1981	9	7.3 \pm 5.8
1982	25	16.0 \pm 4.1
<u>Flock †</u>		
Flock 1	23	12.8 \pm 5.1
Flock 2	11	12.2 \pm 3.5

Source of variation	Analysis of variance	
	DF	Mean square
Breed	1	0.15 NS
Year	1	2.32 *
Flock	1	0.01 NS
Error	30	0.29
Total	33	

† Flock 1 - Primiparturient ewes
 Flock 2 - Multiparturient ewes.

2.6 Expulsion of the placenta

The time interval at which the placenta was voided from each animal were recorded relative to the delivery of the last lamb.

Table 4.40 presents data for the hoggets and the mean interval to expulsion of the placenta. Differences due to the effect of breed, lamb rank and year were found to be not significant. There was a significant interaction between breed and lamb rank ($P < 0.05$). Overall, the mean interval was about 191 min with a range of between 2-5 h. This is shown in Figure 4.8 where the data have been classified according to breed group. The animals were seen only on one occasion eating the placenta.

Table 4.41 shows the effects of flock, breed, lamb rank and year on the interval to expulsion of the placenta for the 2-year-old ewes. The analysis of data revealed that the only significant difference obtained was between years ($P < 0.05$). Overall, the mean interval was about 167 min and usually the most common time recorded was within 3-4 h (Figure 4.8).

Among those 2-year-old ewes delivering their placenta, 3% were seen to eat a small part of it, and 8% of those observed were seen to eat all the placenta. On one occasion a ewe was observed to eat a portion of the placenta from another ewe.

However, overall the total time of delivery (labour and placenta expulsion) was about 4 h for both hoggets and 2-year-old ewes.

Table 4.40. Effects of breed, lamb rank and year on the time of expulsion of the placenta from ewe hoggets.

Classification	Number	Interval to expulsion of placenta (min)
Overall	44	190.8 \pm 6.4
<u>Breed</u>		
Romney	14	180.7 \pm 10.1
BLX	30	200.9 \pm 7.5
<u>Lamb rank</u>		
Single	36	193.0 \pm 5.5
Twin	8	188.7 \pm 11.5
<u>Year</u>		
1979	22	189.5 \pm 9.8
1980	22	192.1 \pm 8.0

Source of variation	Analysis of variance	
	DF	Mean square
Breed	1	0.00 NS
Lamb rank	1	0.00 NS
Year	1	0.01 NS
Breed x lamb rank	1	0.03 *
Breed x year	1	0.00 NS
Lamb rank x year	1	0.00 NS
Error	37	0.00
Total	43	

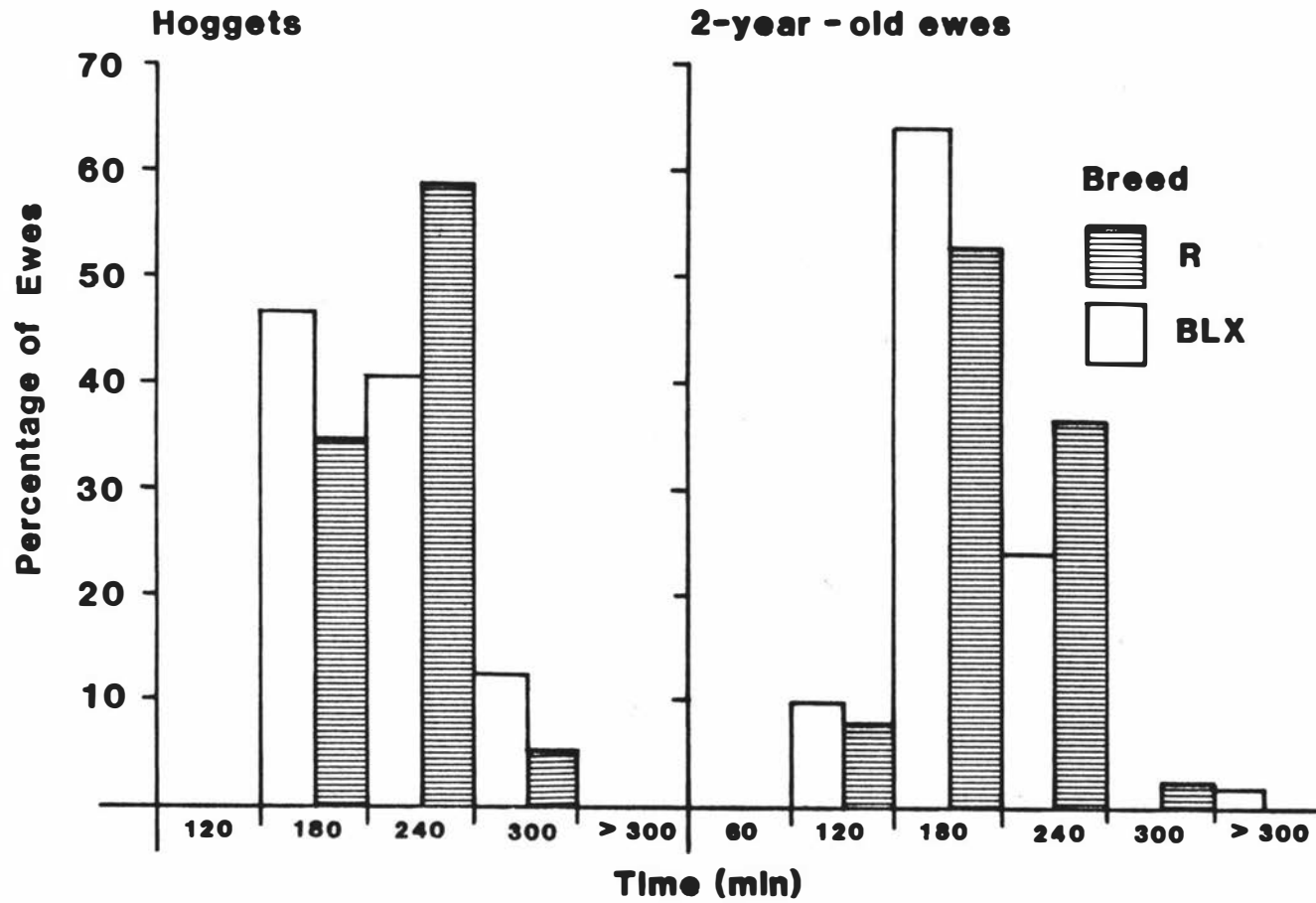
Table 4.41. Effects of flock, breed, lamb rank and year on the time of expulsion of the placenta from two-year-old ewes.

Classification	Number	Interval to expulsion of placenta (min)
Overall	87	166.8 \pm 6.1
<u>Flock</u> †		
Flock 1	59	169.5 \pm 8.6
Flock 2	28	168.1 \pm 5.4
<u>Breed</u>		
Romney	34	167.3 \pm 10.0
BLX	53	166.3 \pm 6.5
<u>Lamb rank</u>		
Single	59	166.4 \pm 6.3
Twin	28	167.2 \pm 10.3
<u>Year</u>		
1981	42	161.5 \pm 9.1
1982	45	172.0 \pm 7.6

Source of variation	Analysis of variance	
	DF	Mean square
Flock	1	0.01 NS
Breed	1	0.00 NS
Lamb rank	1	0.01 NS
Year	1	0.06 *
Flock x breed	1	0.01 NS
Flock x lamb rank	1	0.00 NS
Flock x year	1	0.01 NS
Breed x lamb rank	1	0.00 NS
Breed x year	1	0.02 NS
Lamb rank x year	1	0.00 NS
Error	76	0.01
Total	86	

† Flock 1 - Primiparturient ewes
 Flock 2 - Multiparturient ewes.

Figure 4-8 Time from birth to expulsion of the placenta



2.7 Lamb behaviour

a - Interval from birth to standing.

This was defined as "the interval from delivery of the lamb until it stood on its four feet".

The mean intervals from birth to standing and the effects of breed, lamb rank, sex and year are presented in Table 4.42. There were no significant differences between the Romney and BLX progeny and between males and females in the interval from birth to standing, but there were differences between singles and twins ($P < 0.05$) and between years ($P < 0.01$). Overall, the lambs took about 16 min to stand.

Figure 4.9 shows the distribution of newborn lambs classified according to interval from birth to standing. The data showed that within 20 min of birth, 74% of the lambs were standing on their feet.

A similar analysis was carried out on the data of lambs from 2-year-old ewes and the results are shown in Table 4.43.

It was evident that the effects of breed, lamb rank, sex and year on the mean interval were all small and non-significant. The mean interval from birth to standing was about 16 min and similar to that found with hoggets.

Data within each breed of animals classified according to the interval from birth to standing are given in Figure 4.9. This showed that about 82% were on their feet within 20 min of birth.

The birth weight of the lamb and the time of the lamb standing were not correlated (hoggets, $r = 0.12, NS$; 2-year-old ewes, $r = 0.12, NS$).

Table 4.42. Effects of breed, lamb rank, sex and year on the interval from birth to standing for progeny of hoggets.

Classification	Number	Time from birth - standing (min)
Overall	54	15.9 \pm 2.2
<u>Breed</u>		
Romney	16	14.3 \pm 3.9
BLX	38	17.5 \pm 2.6
<u>Lamb rank</u>		
Single	40	19.9 \pm 2.2
Twin	14	11.9 \pm 3.8
<u>Sex</u>		
Male	27	18.5 \pm 3.1
Female	27	13.3 \pm 3.5
<u>Year</u>		
1979	27	12.4 \pm 3.1
1980	27	19.4 \pm 3.1

Source of variation	Analysis of covariance	
	DF	Mean square
Birth weight	1	0.06
Breed	1	0.03 NS
Lamb rank	1	0.24 *
Sex	1	0.07 NS
Year	1	0.62 **
Breed x lamb rank	1	0.09 NS
Breed x sex	1	0.00 NS
Breed x year	1	0.03 NS
Lamb rank x sex	1	0.01 NS
Lamb rank x year	1	0.14 NS
Sex x year	1	0.00 NS
Error	42	0.06
Total	53	

Figure 4-9 Time from birth to standing for progeny of hoggets and 2-year-old ewes

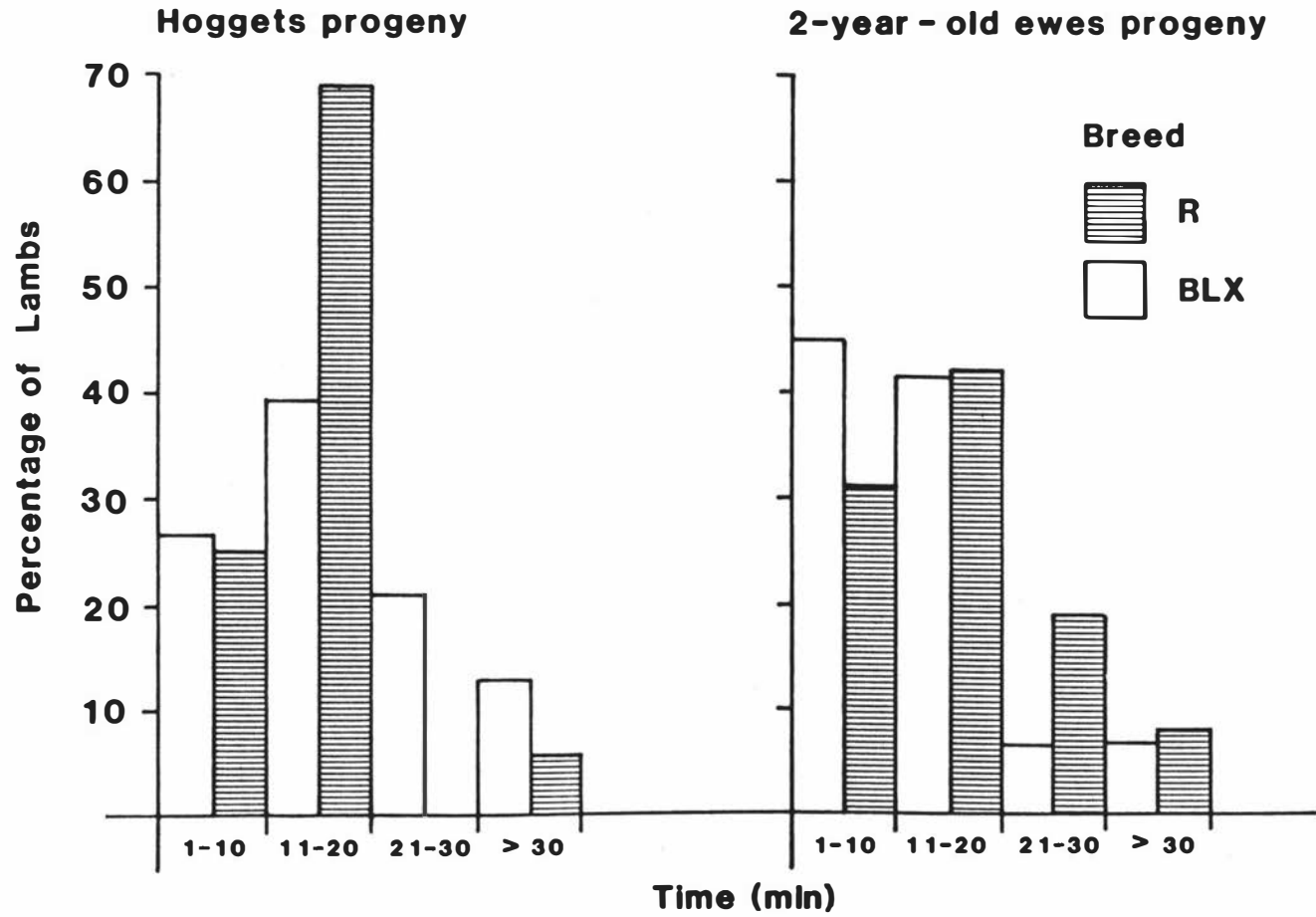


Table 4.43. Effects of breed, lamb rank, sex and year on the interval from birth to standing for progeny of two-year-old ewes.

Classification	Number	Time from birth-standing (min)
Overall	137	15.5 \pm 1.18
<u>Breed</u>		
Romney	48	16.0 \pm 2.0
BLX	89	15.0 \pm 1.2
<u>Lamb rank</u>		
Single	71	15.8 \pm 1.8
Twin	66	15.2 \pm 2.3
<u>Sex</u>		
Male	71	16.4 \pm 1.4
Female	66	14.6 \pm 1.9
<u>Year</u>		
1981	53	17.6 \pm 1.9
1982	84	13.4 \pm 1.3

Source of variation	Analysis of covariance	
	DF	Mean square
Birth weight	1	0.01
Breed	1	0.42 NS
Lamb rank	1	0.03 NS
Sex	1	0.00 NS
Year	1	0.08 NS
Breed x lamb rank	1	0.15 NS
Breed x sex	1	0.11 NS
Breed x year	1	0.02 NS
Lamb rank x sex	1	0.20 NS
Lamb rank x year	1	0.04 NS
Sex x year	1	0.00 NS
Error	125	0.11
Total	136	

b - Interval from standing to sucking.

This interval was defined as that from the time for lambs to stand on their feet until successfully sucking from the udder.

Table 4.44 shows the mean intervals and the effects of different variables involved in the analysis of variance adjusted for birth weight.

There were significant differences between breeds ($P < 0.05$), and twin lambs had a longer mean interval than singles ($P < 0.05$). The effect of the year was found to be significant ($P < 0.001$), while the effect of sex of the lamb was found to be non-significant. Overall the mean interval from standing to sucking was about 35 min (range 3-75 min).

Figure 4.10 shows the distribution of the lambs classified for intervals from standing to sucking. About 60% of the progeny of the BLX hoggets stood on their feet and sucked the udder within 20 min, while 53% of the progeny of the Romneys took more than 30 min and the maximum was about 75 min.

Correlation was found to be not significant between birth weight and time from standing to sucking for the progeny of hoggets ($r = 0.05$).

Table 4.45 shows the interval from standing to sucking for the progeny of 2-year-old ewes.

Results revealed by the analysis indicated that none of the main factors (breed, lamb rank, sex and year) had a significant effect on the interval from standing to sucking. Although the main factors were not significant, a significant breed-by-year interaction ($P < 0.05$) and also a significant lamb rank-by-year interaction ($P < 0.05$) were obtained.

Figure 4.10 shows the distribution of intervals from standing to sucking for the progeny of 2-year-old ewes. The distribution indicates that the majority of the lambs stood and sucked within 20 min.

There was no significant correlation between birth weight and the time from standing to sucking for the progeny of 2-year-old ewes ($r = -0.3$).

Table 4.44. Effects of breed, lamb rank, sex and year on the interval from standing to sucking for progeny of hoggets.

Classification	Number	Time from standing to sucking (min)
Overall	54	35.1 \pm 2.7
<u>Breed</u>		
Romney	16	49.4 \pm 4.6
BLX	38	20.7 \pm 3.1
<u>Lamb rank</u>		
Single	40	24.5 \pm 2.6
Twin	14	45.6 \pm 4.6
<u>Sex</u>		
Male	27	31.2 \pm 3.7
Female	27	38.9 \pm 4.1
<u>Year</u>		
1979	27	22.9 \pm 3.7
1980	27	47.2 \pm 3.7

Source of variation	Analysis of covariance	
	DF	Mean square
Birth weight	1	0.02
Breed	1	0.60 *
Lamb rank	1	0.53 *
Sex	1	0.00 NS
Year	1	2.11 ***
Breed x lamb rank	1	0.34 NS
Breed x sex	1	0.06 NS
Breed x year	1	0.15 NS
Lamb rank x sex	1	0.06 NS
Lamb rank x year	1	0.18 NS
Sex x year	1	0.09 NS
Error	42	0.08
Total	53	

Figure 4-10 Time from standing to sucking for progeny of hoggets and 2-year-old ewes

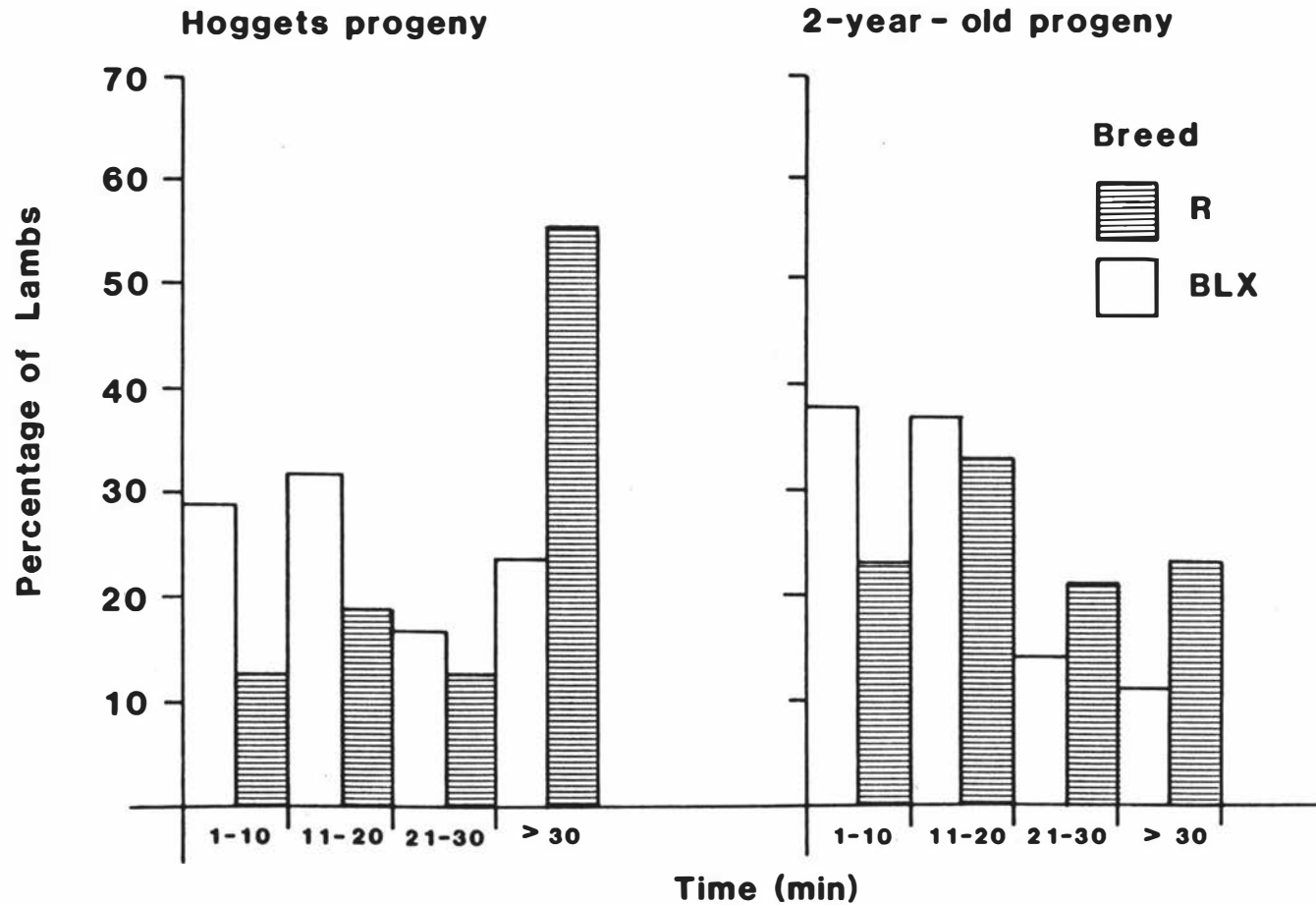


Table 4.45. Effects of breed, lamb rank, sex and year on the interval from standing to sucking for progeny of two-year-old ewes.

Classification	Number	Time from standing to sucking (min)
Overall	137	17.9 \pm 1.8
<u>Breed</u>		
Romney	48	18.6 \pm 3.0
BLX	89	17.2 \pm 1.9
<u>Lamb rank</u>		
Single	71	18.9 \pm 2.8
Twin	66	17.0 \pm 3.6
<u>Sex</u>		
Male	71	20.4 \pm 2.2
Female	66	15.5 \pm 2.9
<u>Year</u>		
1981	53	16.1 \pm 2.9
1982	84	19.7 \pm 2.0

Source of variation	Analysis of covariance	
	DF	Mean square
Birth weight	1	2.22
Breed	1	0.41 NS
Lamb rank	1	0.05 NS
Sex	1	0.06 NS
Year	1	0.60 NS
Breed x lamb rank	1	0.20 NS
Breed x sex	1	0.08 NS
Breed x year	1	0.91 *
Lamb rank x sex	1	0.05 NS
Lamb rank x year	1	0.69 *
Sex x year	1	0.01 NS
Error	125	0.15
Total	136	

Overall, the mean intervals from birth to sucking for hoggets' and 2-year-olds' progeny were found to be 51 and 34 min respectively.

2.8 Desertion of lambs

Two types of desertion of lambs from their mothers were seen:

Temporary - lasting for a period up to 3 hours;

Permanent - where the mother would not accept the lamb at all, even after some effort to "mother-up" the animal and her offspring.

Desertion of the lamb may have been due to long labour and/or difficulties during parturition.

Table 4.46 shows the percentage of hoggets that deserted their lambs. Desertion was not affected by breed and year. Overall, 6% of hoggets deserted their lambs.

Table 4.47 presents the percentage of 2-year-old ewes that deserted their lamb(s) and the effects of different factors involved in the analysis.

The data disclosed that there were no significant differences between all main factors. Overall, the incidence of 2-year-old ewes which deserted their lambs was 5%.

Table 4.46. Incidence of desertion of lambs by hoggets.

Classification	Number	Desertion of lambs (%)
Overall	52	6
<u>Breed</u>		
Romney	18	11
BLX	34	3
<u>Year</u>		
1979	25	8
1980	27	4

Source of variation	Analysis of deviance	
	DF	Deviance
Breed	1	1.36 NS
Year	1	0.41 NS
Residual	49	21.17

Table 4.47. Incidence of desertion of lambs by two-year-old ewes.

Classification	Number	Desertion of lambs (%)
Overall	113	5
<u>Breed</u>		
Romney	44	5
BLX	69	6
<u>Lamb rank</u>		
Single	77	6
Twin	36	3
<u>Year</u>		
1981	47	6
1982	66	5
<u>Flock †</u>		
Flock 1	77	6
Flock 2	36	3

Source of variation	Analysis of deviance	
	DF	Deviance
Breed	1	0.09 NS
Lamb rank	1	0.82 NS
Year	1	0.07 NS
Flock	1	0.70 NS
Residual	108	45.23

† Flock 1 - Primiparturient ewes

Flock 2 - Multiparturient ewes.

2.9 Lamb mortality

Table 4.48 shows for hoggets the distribution of mortality classified according to cause of lamb death.

Estimates of 19.9% mortality (proportion of lambs dead per 100 lambs born) were recorded from the time of lambing until weaning. Overall, 23% of lambs died of dystocia, 32% were premature and 45% died of other causes. The lowest proportion of deaths was noticed in Romney females (13%). Male lambs from both breeds had the highest percentage of deaths. However, the high percentage of premature lambs born (32%) may be due to the effect of shearing, which was very close to the expected starting date of lambing. The proportion of lambs dying of other causes was the highest compared to the other two causes of death (45%). Most lambs in the "other causes" category were born dead or died soon after lambing for different reasons not related to birth stress.

The proportions of dead lambs classified according to the time of death are presented in Table 4.49.

It was clear that most lambs died during parturition or soon after (84%) and a further 13% within 3 days.

Figure 4.11 shows the distribution of lamb mortality related to birth weight of lambs. Most of the lambs that died had average birth weights of less than 3 kg, and 29% of dead lambs were between 3-4 kg. Lambs that had 5-6 kg birthweights, which are quite high for hoggets, showed 13% mortality.

Table 4.50 presents for 2-year-old ewes the distribution of mortality classified according to cause of lamb death.

Estimates of 16.4% mortality were recorded in this study from the time of lambing until weaning. Overall, 41% of those lambs died of dystocia, 27% of lambs were born dead, and 32% of the lambs died of "other" causes. Lambs born to Romney dams had the highest percentage of deaths due to dystocia (58%), while lambs born to BLX dams had 30.6%. More males (47%) died of dystocia than females (28%) and more lambs died of dystocia in 1981 than in 1982.

Table 4.51 shows the distribution of dead lambs classified according to time of death. Overall, 77% of lambs were born dead due to different reasons, 6% die soon after birth to 3 days after lambing, and 17% died from the 4th day onwards.

The distribution of dead lambs relative to the birth rank are shown in Table 4.52.

Most deaths were among single-born lambs (58%), but some were also evident among one member of a twin pair (32%) and especially in twin lambs from BLX ewes. It was also noticed that the death of both twins was higher in BLX progeny lambs.

Figure 4.12 shows for 2-year-old ewes the distribution of dead lambs relative to birth weights. The majority (49%) of dead lambs had birth weights of 2-4 kg; about 48% of the lambs were in the 5-7 kg range, and this in most cases was associated with dystocia.

Table 4.48. Distribution of dead lambs classified according to cause of death (progeny of hoggets).

Cause of death	Romney		BLX		Total
	Male	Female	Male	Female	
Dystocia	2	2	2	1	7 (23%)
Prematurity	2	1	4	3	10 (32%)
"Other"	3	1	5	5	14 (45%)
Total	7 (23%)	4 (13%)	11 (35%)	9 (29%)	31

Table 4.49. Distribution of dead lambs classified according to time of death (progeny of hoggets).

Time of death	Romney		BLX		Total
	Male	Female	Male	Female	
At birth	6	4	10	6	26 (84%)
1 - 3 days	1	-	1	2	4 (13%)
4 days - weaning	-	-	-	1	1 (3%)
Total	7 (23%)	4 (13%)	11 (35%)	9 (29%)	31

Figure 4-11&12 Distribution of birthweights (kg) of dead lambs

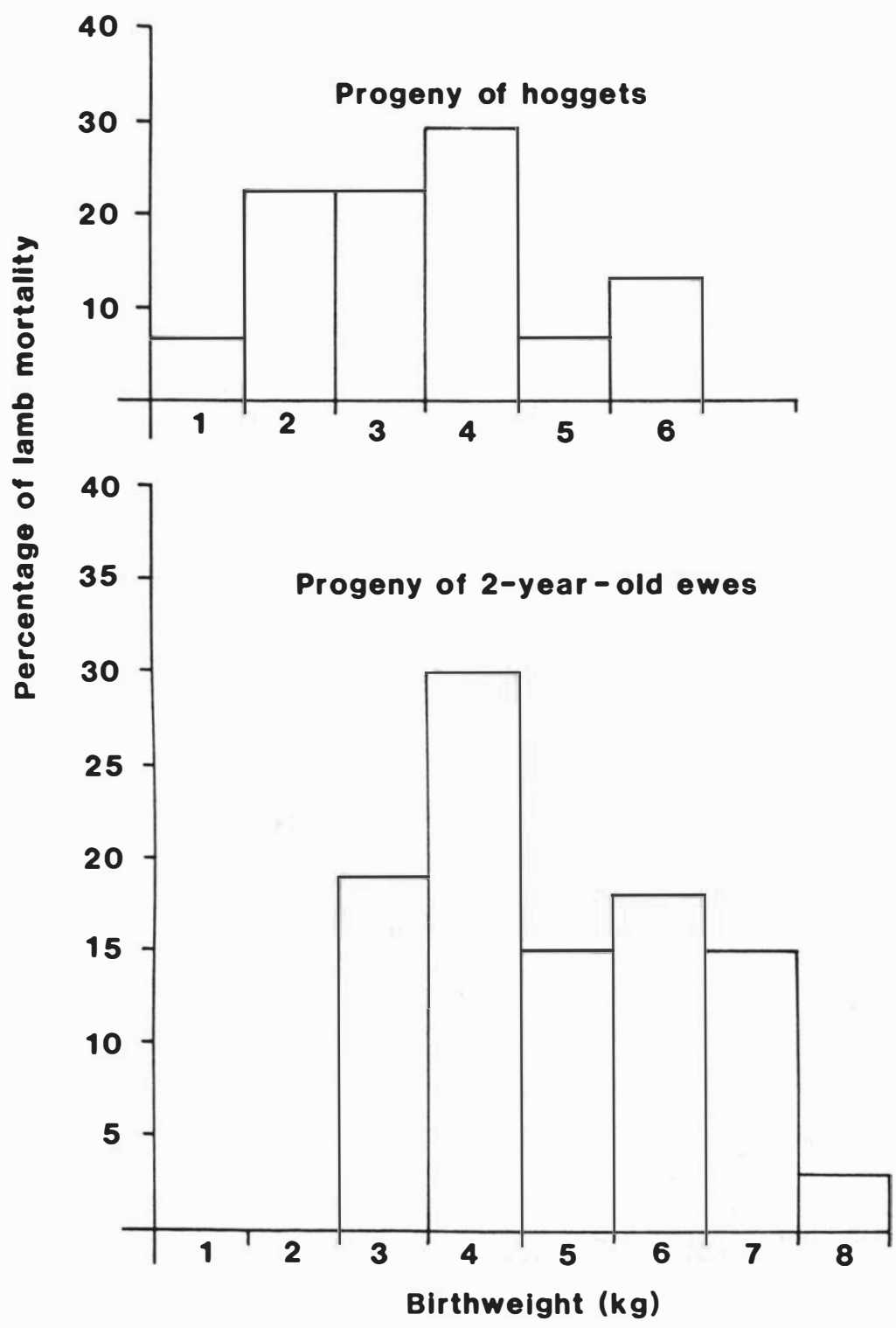


Table 4.50. Distribution of dead lambs classified according to cause of death (progeny of two-year-old ewes).

Classification	Cause of death			Total
	Dystocia	Born dead	"Other"	
<u>Breed</u>				
Romney	17 (58%)	6 (21%)	6 (21%)	29
BLX	15 (30.6%)	15 (30.6%)	19 (38.8%)	49
<u>Sex</u>				
Male	25 (47%)	13 (25%)	15 (28%)	53
Female	7 (28%)	8 (32%)	10 (40%)	25
<u>Year</u>				
1981	23 (55%)	11 (26%)	8 (19%)	42
1982	9 (25%)	10 (28%)	17 (47%)	36
Total	32 (41%)	21 (27%)	25 (32%)	78

Table 4.51. Distribution of dead lambs classified according to time of death (progeny of two-year-old ewes).

Classification	Time of death			Total
	Born dead	1 - 3 days	4 days - weaning	
<u>Breed</u>				
Romney	24	1	4	29
BLX	36	4	9	49
<u>Sex</u>				
Male	43	4	6	53
Female	17	1	7	25
<u>Year</u>				
1981	34	4	4	42
1982	26	1	9	36
Total	60 (77%)	5 (6%)	13 (17%)	78

Table 4.52. Distribution of dead lambs classified according to lamb rank (progeny of two-year-old ewes).

Classification	Single	One of twins	Both twin	Total
<u>Breed</u>				
Romney	22	5	2	29
BLX	23	20	6	49
<u>Sex</u>				
Male	30	15	8	53
Female	15	10	-	23
<u>Year</u>				
1981	31	9	2	42
1982	14	16	6	36
Total	45 (58%)	25 (32%)	8 (10%)	78

3. GROWTH OF THE LAMB AND MILK PRODUCTION OF THE EWE

3.1 Birth weight

Analyses were made on two sets of data comprising birth weights from (a) all lambs born, and
(b) weaned lambs.

The difference in number of observations for the two sets represents the lamb mortality.

Lambs from hoggets

The effects of breed, birth rank, sex and year on birth weight of all lambs and of weaned lambs are shown in Table 4.53.

Overall the birth weights for all lambs were 3.62 ± 0.1 kg, with means of 3.80 kg and 3.44 kg for Romney and BLX progeny, respectively ($P < 0.05$). The effect of birth rank on the birth weight was highly significant ($P < 0.001$). Single lambs were heavier at birth than twins. Birth weight of the lambs was influenced by year ($P < 0.05$). The sex effect was found to be negligible.

Analysis of birth weights of weaned lambs failed to reveal any significant breed effect; other results were nearly the same as for all lambs.

Lambs from two-year-old ewes

Table 4.54 presents the average birth weights for all lambs and weaned lambs together with a summary of the analysis of variance.

Essentially the mean values revealed for each set of data were: mean birth weight for all lambs born was 4.4 kg. The difference in birth weight between breeds was not significant, although the progeny of BLX ewes were slightly heavier at birth than lambs born to Romneys. The largest differences in birth weight were between singles and twins (5.07 kg, v. 3.72 kg, $P < 0.001$). A significant sex effect on birth weight was clear ($P < 0.001$) as was that due to the year ($P < 0.001$). Differences between flocks were small and non-significant.

Table 4.53. The effects of breed, lamb rank, sex and year on the birth weights (kg) of all lambs and weaned lambs from hoggets.

Classification	<u>Birth weights</u>			
	<u>All lambs</u>		<u>Weaned lambs</u>	
	Number	Mean \pm S.E.	Number	Mean \pm S.E.
Overall	156	3.62 \pm 0.1	125	3.80 \pm 0.1
<u>Breed</u>				
Romney	58	3.80 \pm 0.2	47	4.00 \pm 0.2
BLX	98	3.44 \pm 0.1	78	3.59 \pm 0.1
<u>Lamb rank</u>				
Single	120	3.97 \pm 0.1	98	4.12 \pm 0.1
Twin	36	3.27 \pm 0.2	27	3.47 \pm 0.2
<u>Sex</u>				
Male	74	3.63 \pm 0.1	57	3.92 \pm 0.1
Female	82	3.60 \pm 0.1	68	3.67 \pm 0.1
<u>Year</u>				
1979	73	3.49 \pm 0.1	61	3.65 \pm 0.1
1980	83	3.74 \pm 0.1	64	3.94 \pm 0.1

Source of variation	Analysis of variance		
	DF	All lambs	Mean square Weaned lambs
Breed	1	4.10 *	1.92 NS
Lamb rank	1	15.42 ***	12.50 ***
Sex	1	0.67 NS	0.98 NS
Year	1	4.53 *	5.83 ***
Breed x lamb rank	1	0.03 NS	0.78 NS
Breed x sex	1	0.01 NS	0.27 NS
Breed x year	1	0.05 NS	0.00 NS
Lamb rank x sex	1	1.13 NS	0.07 NS
Lamb rank x year	1	0.91 NS	0.74 NS
Sex x year	1	3.30 NS	1.46 NS
Error	145	0.88	0.51 (114)
Total	155		124

Table 4.54. Effects of breed, lamb rank, sex, year and flock on the birth weights (kg) of all lambs and weaned lambs from two-year-old ewes.

Classification	<u>Birth weight</u>			
	<u>All lambs</u>		<u>Weaned lambs</u>	
	Number	Mean \pm S.E.	Number	Mean \pm S.E.
Overall	477	4.40 \pm 0.04	399	4.43 \pm 0.05
<u>Breed</u>				
Romney	186	4.26 \pm 0.07	154	4.29 \pm 0.07
BLX	291	4.53 \pm 0.05	245	4.57 \pm 0.05
<u>Lamb rank</u>				
Single	283	5.07 \pm 0.05	240	5.06 \pm 0.05
Twin	194	3.72 \pm 0.07	159	3.80 \pm 0.08
<u>Sex</u>				
Male	257	4.55 \pm 0.05	203	4.58 \pm 0.06
Female	220	4.25 \pm 0.06	196	4.28 \pm 0.06
<u>Year</u>				
1981	219	4.66 \pm 0.07	177	4.70 \pm 0.07
1982	258	4.13 \pm 0.05	222	4.15 \pm 0.05
<u>Flock</u>				
First lambing	316	4.31 \pm 0.05	267	4.33 \pm 0.05
Second lambing	161	4.48 \pm 0.07	132	4.53 \pm 0.07

Table 4.54 (continued)

Source of variation	DF	Analysis of variance	
		All lambs	Weaned lambs
Breed	1	0.04 NS	0.95 NS
Lamb rank	1	253.86 ***	185.76 ***
Sex	1	11.10 ***	6.34 ***
Year	1	33.54 ***	28.62 ***
Flock	1	2.04 NS	2.81 *
Breed x lamb rank	1	1.91 NS	1.13 NS
Breed x sex	1	0.68 NS	1.54 NS
Breed x year	1	0.94 NS	0.09 NS
Breed x flock	1	0.39 NS	0.17 NS
Lamb rank x sex	1	0.56 NS	0.00 NS
Lamb rank x year	1	0.71 NS	0.45 NS
Lamb rank x flock	1	0.39 NS	0.25 NS
Sex x year	1	0.18 NS	0.20 NS
Sex x flock	1	0.75 NS	0.03 NS
Year x flock	1	0.02 NS	0.00 NS
Error	461	0.58	0.50 (383 DF)
Total	476		398

3.2 Weaning weight

Two analyses were done to examine the data on weaning weights of the lambs from hoggets.

The first model examined the influence of breed, lamb rank, sex and year and the second model examined the effects of milking procedure, breed and year on the weaning weights.

Table 4.55 presents the results of the first model. Overall the average weaning weight was 17.2 kg.

The effects of breed and sex were not significant, although the progeny of BLX ewes were slightly heavier than those from the Romneys. Lambs born as singles weighed 3.5 kg more at weaning than lambs born as twins ($P < 0.001$), also there was a significant effect due to year ($P < 0.01$).

The results of the second model are presented in Table 4.56.

Overall the mean weaning weight of the single lambs was 19.1 kg.

The lambs of the milked group had similar weaning weights to those from the non-milked group. Examination of the results showed that the effect of the year was the only significant one ($P < 0.001$).

Data on the weaning weights of the lambs from 2-year-old ewes are given in Table 4.57. The analysis of variance revealed a significant difference ($P < 0.01$) between progeny from Romney and BLX ewes (25.7 kg v. 27.7 kg respectively). Single-born lambs were significantly heavier at weaning than lambs born as twins (29.3 v. 24.2 kg, $P < 0.001$). Male lambs were markedly heavier than the female lambs ($P < 0.001$). The year effect was also significant ($P < 0.001$). The data also show that the progeny of the 2-year-old ewes which lambed as hoggets were 0.5 kg heavier at weaning than the progeny of the 2-year-old ewes which had lambed for the first time. This effect was not statistically significant.

Table 4.55. Effects of breed, lamb rank, sex and year on the weaning weights (kg) of lambs from ewe hoggets.

Classification	Number	Weaning weights (mean \pm S.E.)
Overall	125	17.2 \pm 0.3
<u>Breed</u>		
Romney	47	16.8 \pm 0.6
BLX	78	17.5 \pm 0.4
<u>Lamb rank</u>		
Single	98	18.9 \pm 0.3
Twin	27	15.4 \pm 0.5
<u>Sex</u>		
Male	57	17.0 \pm 0.5
Female	68	17.3 \pm 0.4
<u>Year</u>		
1979	61	17.7 \pm 0.4
1980	64	16.6 \pm 0.5

Source of variation	Analysis of covariance	
	DF	Mean square
Birth day	1	130.252
Breed	1	0.304 NS
Lamb rank	1	236.933 ***
Sex	1	0.202 NS
Year	1	65.420 **
Breed x lamb rank	1	0.002 NS
Breed x sex	1	0.476 NS
Breed x year	1	23.388 NS
Lamb rank x sex	1	7.489 NS
Lamb rank x year	1	18.456 NS
Sex x year	1	1.181 NS
Error	113	6.892
Total	124	

Table 4.56. Effects of milking the ewe, breed and year on the weaning weights (kg) of single lambs from ewe hoggets.

Classification	Number	Weaning weights (mean \pm S.E.)
Overall	98	19.1 \pm 0.4
<u>Milking</u>		
Milked	52	18.8 \pm 0.3
Not milked	46	19.0 \pm 0.3
<u>Breed</u>		
Romney	40	18.7 \pm 0.7
BLX	58	19.5 \pm 0.6
<u>Year</u>		
1979	47	19.9 \pm 0.5
1980	51	18.3 \pm 0.6

Source of variation	Analysis of covariance	
	DF	Mean square
Birth day	1	201.995
Milking	1	9.720 NS
Breed	1	4.801 NS
Year	1	93.715 ***
Milking x breed	1	0.240 NS
Milking x year	1	12.043 NS
Breed x year	1	11.049 NS
Error	90	5.764
Total	97	

Table 4.57. Effects of breed, lamb rank, sex, year and flock on the weaning weights (kg) of lambs from two-year-old ewes.

Classification	Number	Weaning weights (mean \pm S.E.)
Overall	399	26.7 \pm 0.2
<u>Breed</u>		
Romney	154	25.7 \pm 0.4
BLX	245	27.7 \pm 0.3
<u>Lamb rank</u>		
Single	240	29.3 \pm 0.3
Twin	159	24.2 \pm 0.4
<u>Sex</u>		
Male	203	28.2 \pm 0.3
Female	196	25.3 \pm 0.3
<u>Year</u>		
1981	177	27.8 \pm 0.4
1982	222	25.7 \pm 0.3
<u>Flock</u>		
First lambing	267	26.5 \pm 0.4
Second lambing	132	27.0 \pm 0.3

Table 4.57 (continued)

Analysis of covariance		
Source of variation	DF	Mean square
Birth day	1	2811.059
Breed	1	116.857 **
Lamb rank	1	3144.882 ***
Sex	1	762.234 ***
Year	1	169.266 ***
Flock	1	2.0136 NS
Breed x lamb rank	1	1.759 NS
Breed x sex	1	14.806 NS
Breed x year	1	1.203 NS
Breed x flock	1	0.004 NS
Lamb rank x sex	1	26.363 NS
Lamb rank x year	1	41.301 NS
Lamb rank x flock	1	25.576 NS
Sex x year	1	10.263 NS
Sex x flock	1	8.961 NS
Year x flock	1	12.656 NS
Error	382	14.369
Total	398	

3.3 Daily weight gain

The weight gain per day for all lambs was computed as follows:

$$\text{Weight gain per day (kg)} = \frac{\text{Weaning weight} - \text{Birth weight}}{\text{Age at weaning (days)}}$$

Further weight gain information was recorded on the lambs whose mothers were milked by hand. These lambs were weighed at 3-weekly intervals so that more accurate changes in daily weight gain could be computed, than is possible where only birth weights and weaning weights are available. The more extensive data are given in Section 3.7.

Lambs from hoggets

Table 4.58 shows the effects of breed, lamb rank, sex and year on daily weight gains of progeny from hoggets together with the analysis of variance.

The results showed that the effects of breed and sex were not significant. The effects of lamb rank and year were significant ($P < 0.001$), but there was a significant lamb rank-by-year interaction ($P < 0.05$).

Another model was fitted and the effects of milking, breed and year on daily gain were studied for single lambs only. These results are shown in Table 4.59.

Milking of the ewes did not affect the daily weight gains. The mean weight gains differed between years ($P < 0.001$).

Lambs from two-year-old ewes

Table 4.60 presents the mean weights and the analysis of factors causing variation in the progeny of 2-year-old ewes.

Examination of the results shows that there was a significant difference between breeds ($P < 0.05$). The single lambs had daily weight gains higher than those for twins ($P < 0.001$). Male lambs grew significantly ($P < 0.001$) faster than the females. The year effect was found to be significant ($P < 0.001$). Differences between flocks were non-significant.

Table 4.58. Effects of breed, lamb rank, sex and year on daily gains (kg) to weaning of lambs from hoggets.

Classification	Number	Daily gains (mean \pm S.E.)
Overall	125	0.192 \pm 0.004
<u>Breed</u>		
Romney	47	0.183 \pm 0.007
BLX	78	0.201 \pm 0.005
<u>Lamb rank</u>		
Single	98	0.213 \pm 0.004
Twin	27	0.171 \pm 0.008
<u>Sex</u>		
Male	57	0.187 \pm 0.006
Female	68	0.197 \pm 0.006
<u>Year</u>		
1979	61	0.208 \pm 0.006
1980	64	0.176 \pm 0.006

Source of variation	Analysis of variance	
	DF	Mean square
Breed	1	0.002 NS
Lamb rank	1	0.030 ***
Sex	1	0.00 NS
Year	1	0.052 ***
Breed x lamb rank	1	0.00 NS
Breed x sex	1	0.003 NS
Breed x year	1	0.003 NS
Lamb rank x sex	1	0.003 NS
lamb rank x year	1	0.008 *
Sex x year	1	0.00 NS
Error	114	0.001
Total	124	

Table 4.59. Effects of milking the ewe, breed and year on the daily weight gains (kg) to weaning of single lambs from hoggets.

Classification	Number	Daily gains (mean \pm S.E.)
Overall	98	0.215 \pm 0.005
<u>Milking</u>		
Milked	52	0.213 \pm 0.004
Not milked	46	0.212 \pm 0.005
<u>Breed</u>		
Romney	40	0.206 \pm 0.009
BLX	58	0.223 \pm 0.006
<u>Year</u>		
1979	47	0.237 \pm 0.007
1980	51	0.192 \pm 0.008

Analysis of variance

Source of variation	DF	Mean square
Milking	1	0.002 NS
Breed	1	0.002 NS
Year	1	0.059 ***
Milking x breed	1	0.000 NS
Milking x year	1	0.002 NS
Breed x year	1	0.002 NS
Error	91	0.001
Total	97	

Table 4.60. Effects of breed, lamb rank, sex, year and flock on the daily weight gains (kg) of lambs from two-year-old ewes.

Classification	Number	Daily gains (mean \pm S.E.)
Overall	399	0.260 \pm 0.003
<u>Breed</u>		
Romney	154	0.249 \pm 0.004
BLX	245	0.271 \pm 0.003
<u>Lamb rank</u>		
Single	240	0.284 \pm 0.003
Twin	159	0.237 \pm 0.004
<u>Sex</u>		
Male	203	0.275 \pm 0.003
Female	196	0.246 \pm 0.004
<u>Year</u>		
1981	177	0.291 \pm 0.004
1982	222	0.229 \pm 0.003
<u>Flock</u>		
First lambing	267	0.261 \pm 0.004
Second lambing	132	0.259 \pm 0.003

Table 4.60 (continued)

Source of variation	Analysis of variance	
	DF	Mean square
Breed	1	0.009 *
Lamb rank	1	0.377 ***
Sex	1	0.067 ***
Year	1	0.327 ***
Flock	1	0.000 NS
Breed x lamb rank	1	0.000 NS
Breed x sex	1	0.001 NS
Breed x year	1	0.000 NS
Breed x flock	1	0.000 NS
Lamb rank x sex	1	0.003 NS
Lamb rank x year	1	0.002 NS
Lamb rank x flock	1	0.006 NS
Sex x year	1	0.002 NS
Sex x flock	1	0.001 NS
Year x flock	1	0.001 NS
Error	383	0.002
Total	398	

3.4 Lamb survival

Table 4.61 presents the means and the analysis of deviance for the lambs from hoggets. Examination of the results shows that there were no significant differences between breeds, lamb rank, sex and year in lamb survival. However, overall survival to weaning for the progeny of the hoggets was 80.1%.

Table 4.62 shows lamb survival from 2-year-old ewes. Results showed that a higher proportion of female lambs survived than male lambs (89.1 v 79.0%; $P < 0.01$). There were significant interactions between breed and lamb rank ($P < 0.05$), breed and sex ($P < 0.05$) and year-by-flock ($P < 0.05$).

Table 4.61. Effects of breed, lamb rank, sex and year on the survival of lambs until weaning from ewe hoggets.

Classification	Number	Survival to weaning (%)
Overall	156	80.1
<u>Breed</u>		
Romney	58	81.0
BLX	98	79.6
<u>Lamb rank</u>		
Single	120	81.2
Twin	36	75.0
<u>Sex</u>		
Male	74	77.0
Female	82	82.9
<u>Year</u>		
1979	73	83.6
1980	83	77.1

Source of variation	Analysis of deviance	
	DF	Deviance
Breed	1	0.05 NS
Lamb rank	1	0.70 NS
Sex	1	0.76 NS
Year	1	1.16 NS
Breed x lamb rank	1	1.25 NS
Breed x sex	1	0.00 NS
Breed x year	1	0.05 NS
Lamb rank x sex	1	2.86 NS
Lamb rank x year	1	0.01 NS
Sex x year	1	1.07 NS
Residual	145	147.65

Table 4.62. Effects of breed, birthrank, sex, year and flock on lambs' survival to weaning from two-year-old ewes.

Classification	Number	Survival to weaning (%)
Overall	477	83.6
<u>Breed of dam</u>		
Romney	186	82.8
BLX	291	84.2
<u>Birth rank</u>		
Single	283	84.8
Twin	194	82.0
<u>Sex</u>		
Male	257	79.0
Female	220	89.1
<u>Year</u>		
1981	219	80.8
1982	258	86.0
<u>Flock</u>		
First lambing	316	84.5
Second lambing	161	82.0

Table 4.62 (continued)

Source of variation	Analysis of deviance	
	DF	Deviance
Breed	1	0.16 NS
Lamb rank	1	0.82 NS
Sex	1	8.74 **
Year	1	3.29 NS
Flock	1	0.63 NS
Breed x lamb rank	1	4.04 *
Breed x sex	1	4.91 *
Breed x year	1	0.03 NS
Breed x flock	1	1.68 NS
Lamb rank x sex	1	2.62 NS
Lamb rank x year	1	0.61 NS
Lamb rank x flock	1	0.03 NS
Sex x year	1	0.02 NS
Sex x flock	1	0.34 NS
Year x flock	1	5.27 *
Residual	461	391.78

3.5 Milk yield

Because the data on milk yield were from hoggets that were milked on 3 or 4 occasions, two sets of analyses were carried out using data from 52 hoggets milked at 3 stages of lactation, and 16 of the above group that were milked 4 times.

Table 4.63 shows the influence of breed, year and sex on the milk yield (l/day) at 3 stages of lactation.

Differences between stages of lactation were significant ($P < 0.001$). Although the difference due to breed effect was significant ($P < 0.05$), a significant stage of lactation-by-breed interaction was revealed by the analysis ($P < 0.05$). The analysis also showed that there was a stage-by-year interaction ($P < 0.05$). Sex of lamb had no significant effect on milk yield. The highest milk yield was at the first stage of lactation (about 3 weeks after lambing) and decreased with the progress of lactation (Figure 4.13).

Similar analyses were carried out on the data from the 16 hoggets and the mean values are presented in Table 4.64.

These results showed that the only significant difference was between stages of lactation ($P < 0.001$). The shape of the lactation curve is not well defined because only 3 points were determined, but overall both breeds and groups showed similar declines as lactation progressed.

The influence of flock, breed, year and sex of lamb on the milk yield of 2-year-old ewes which were all examined at four stages of lactation are presented in Table 4.65 and Figure 4.14.

Differences between stages of lactation were significant ($P < 0.001$). The effect of the breed on milk yield was significant ($P < 0.001$), the results showing that BLX ewes produced more milk (l/day) than Romneys.

There was a significant stage-by-year interaction ($P < 0.001$). The effects of other factors were non-significant.

The shape of the lactation curve (4 points) was similar for animals of each of the breeds and from the two flocks, and according to the sex of the lamb being suckled. There was some difference in the overall appearance of the shape of the curve between the two years.

Table 4.63. Effects of breed, year and sex on the milk yield (l/day) at different stages of lactation for ewe hoggets.

Classification	Number	Weeks after lambing		
		3	6	9
Overall	52	1.56 \pm 0.005	1.18 \pm 0.005	0.78 \pm 0.03
<u>Breed</u>				
Romney	25	1.47 \pm 0.08	1.04 \pm 0.07	0.74 \pm 0.05
BLX	27	1.65 \pm 0.07	1.33 \pm 0.07	0.81 \pm 0.05
<u>Year</u>				
1979	24	1.45 \pm 0.08	1.22 \pm 0.07	0.81 \pm 0.05
1980	28	1.67 \pm 0.07	1.14 \pm 0.07	0.74 \pm 0.05
<u>Sex</u>				
Male	26	1.50 \pm 0.08	1.10 \pm 0.07	0.74 \pm 0.05
Female	26	1.62 \pm 0.08	1.27 \pm 0.07	0.81 \pm 0.05

Repeated-measurements analysis of variance

Source of variation	DF	Chi-square	Significance
Stages	2	100.0	***
Breed	1	5.7	*
Year	1	0.2	NS
Sex	1	2.9	NS
Breed x year	1	0.0	NS
Breed x sex	1	0.0	NS
Year x sex	1	1.1	NS
Stages x breed	2	8.3	*
Stages x year	2	7.6	*
Stages x sex	2	2.2	NS
Stages x breed x year	2	0.9	NS
Stages x breed x sex	2	0.7	NS
Stages x year x sex	2	3.9	NS

Number of observations per stage - 52

Figure 4-13 Milk yield for ewe hoggets

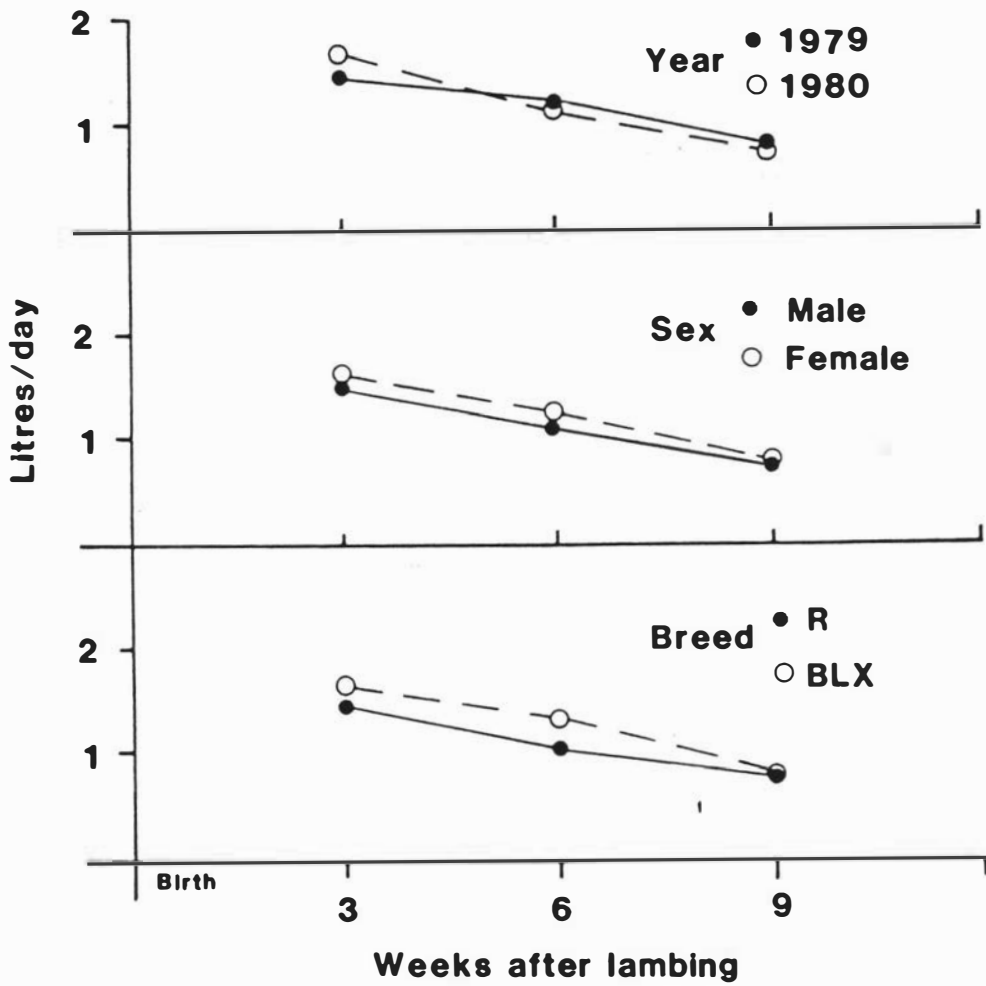


Table 4.64. Effects of breed and sex on the milk yield (l/day) of 16 hoggets recorded over 12 weeks at different stages of lactation.

Classification	Number	Weeks after lambing			
		3	6	9	12
Overall	16	1.78 ± 0.15	1.18 ± 0.09	0.813 ± 0.07	0.630 ± 0.05
<u>Breed</u>					
Romney	8	1.76 ± 0.21	1.20 ± 0.13	0.828 ± 0.10	0.540 ± 0.07
BLX	8	1.80 ± 0.21	1.17 ± 0.13	0.798 ± 0.10	0.720 ± 0.07
<u>Sex</u>					
Male	8	1.78 ± 0.21	1.26 ± 0.13	0.805 ± 0.10	0.660 ± 0.07
Female	8	1.78 ± 0.21	1.11 ± 0.13	0.820 ± 0.10	0.660 ± 0.07

Table 4.64 (continued).

Repeated-measurements analysis of variance

Source of variation	DF	Chi-square	Significance
Stages	3	24.5	***
Breed	1	0.3	NS
Sex	1	0.2	NS
Breed x sex	1	0.6	NS
Stages x breed	3	2.2	NS
Stages x sex	3	1.2	NS
Stages x breed x sex	3	0.1	NS

Number of observations per stage - 16

Table 4.65. Effects of flock, breed, year and sex on the milk yield (l/day) at different stages of lactation for two-year-old ewes.

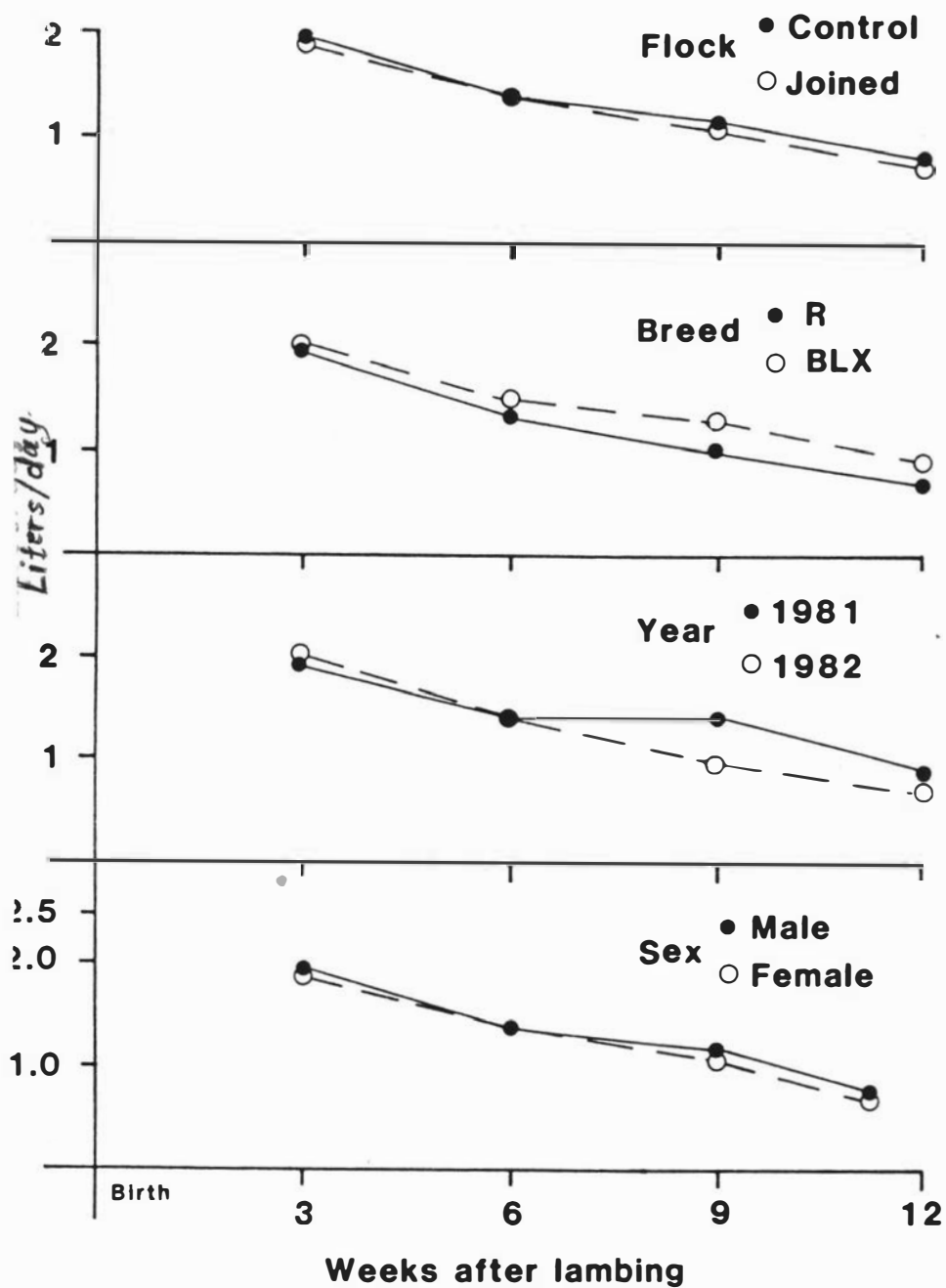
Classification	Number	3	6	9	12
Stage and overall average	61	1.943 ± 0.1	1.388 ± 0.1	1.159 ± 0.1	0.793 ± 0.1
<u>Flock</u>					
Control	30	1.992 ± 0.1	1.388 ± 0.1	1.238 ± 0.1	0.832 ± 0.1
Joined	31	1.895 ± 0.1	1.388 ± 0.1	1.080 ± 0.1	0.754 ± 0.1
<u>Breed</u>					
Romney	30	1.828 ± 0.1	1.279 ± 0.1	1.060 ± 0.1	0.672 ± 0.1
BLX	31	2.059 ± 0.1	1.497 ± 0.1	1.278 ± 0.1	0.914 ± 0.1
<u>Year</u>					
1981	31	1.841 ± 0.1	1.383 ± 0.1	1.378 ± 0.1	0.864 ± 0.1
1982	30	2.046 ± 0.1	1.392 ± 0.1	0.940 ± 0.1	0.722 ± 0.1
<u>Sex</u>					
Male	29	1.959 ± 0.1	1.400 ± 0.1	1.199 ± 0.1	0.840 ± 0.1
Female	32	1.928 ± 0.1	1.375 ± 0.1	1.119 ± 0.1	0.747 ± 0.1

Table 4.65 (continued).

Repeated-measurements analysis of variance			
Source of variation	DF	Chi-square	Significance
Stages	3	88.9	***
Flock	1	1.8	NS
Breed	1	11.9	***
Year	1	1.2	NS
Sex	1	1.0	NS
Flock x breed	1	3.7	NS
Flock x year	1	0.1	NS
Flock x sex	1	0.0	NS
Breed x year	1	0.8	NS
Breed x sex	1	0.0	NS
Year x sex	1	1.0	NS
Stages x flock	3	1.7	NS
Stages x breed	3	0.1	NS
Stages x year	3	15.7	***
Stages x sex	3	0.3	NS
Stages x flock x breed	3	3.0	NS
Stages x flock x year	3	0.4	NS
Stages x flock x sex	3	5.1	NS
Stages x breed x year	3	2.9	NS
Stages x breed x sex	3	1.4	NS
Stages x year x sex	3	1.7	NS

Number of observations per stage - 61

Figure 4-14 Milk yield for 2-year-old ewes



3.6 Milk composition

The samples of milk were analysed for percentages of protein and fat .

a. Milk protein

Hoggets

A similar method for analysis of these data was used to that used for milk yield.

Table 4.66 and Figure 4.15 show the mean percentages of milk protein at different stages of lactation. The results showed that differences between stages of lactation were significant ($P < 0.001$). Romney and BLX hoggets differed significantly between the different stages of lactation ($P < 0.01$). The effect of the year across stages of lactation was significant ($P < 0.001$). The analysis also revealed a significant interaction between stages and breed-by-year ($P < 0.05$).

Data from the group of 16 animals are presented in Table 4.67.

These results show that the only significant difference in milk protein was between stages of lactation ($P < 0.001$).

Two-year-old ewes

Table 4.68 shows the data on milk protein percentage from 2-year-old ewes.

Results revealed by the analysis indicated that the percentage of milk protein significantly changed between different stages of lactation ($P < 0.001$). Although the difference between years was significant ($P < 0.001$), the analysis also indicated a significant stages-by-year interaction ($P < 0.001$). There was also an interaction between breed and sex ($P < 0.01$). The effects of flock, breed and sex of lamb were small (Figure 4.16).

Table 4.66. Effects of breed, year and sex on the percentage milk protein at different stages of lactation for ewe hoggets.

Classification	Number	Weeks after lambing		
		3	6	9
Overall	52	4.52 ± 0.06	4.76 ± 0.05	4.98 ± 0.05
<u>Breed</u>				
Romney	25	4.50 ± 0.09	4.77 ± 0.07	5.09 ± 0.08
BLX	27	4.58 ± 0.08	4.76 ± 0.06	4.87 ± 0.08
<u>Year</u>				
1979	24	4.61 ± 0.08	4.93 ± 0.07	4.94 ± 0.08
1980	28	4.43 ± 0.08	4.60 ± 0.06	5.02 ± 0.08
<u>Sex</u>				
Male	26	4.69 ± 0.08	4.82 ± 0.07	5.02 ± 0.08
Female	26	4.36 ± 0.08	4.71 ± 0.06	4.94 ± 0.08

Table 4.66 (continued).

Repeated-measurements analysis of variance

Source of variation	DF	Chi-square	Significance
Stages	2	37.3	***
Breed	1	0.0	NS
Year	1	2.6	NS
Sex	1	3.6	NS
Breed x year	1	0.4	NS
Breed x sex	1	1.2	NS
Year x sex	1	0.0	NS
Stages x breed	2	11.2	**
Stages x year	2	16.2	***
Stages x sex	2	4.2	NS
Stages x breed x year	2	7.2	*
Stages x breed x sex	2	1.0	NS
Stages x year x sex	2	3.2	NS

Number of observations per stage - 52

Figure 4-15 Milk protein percentages for ewe hoggets

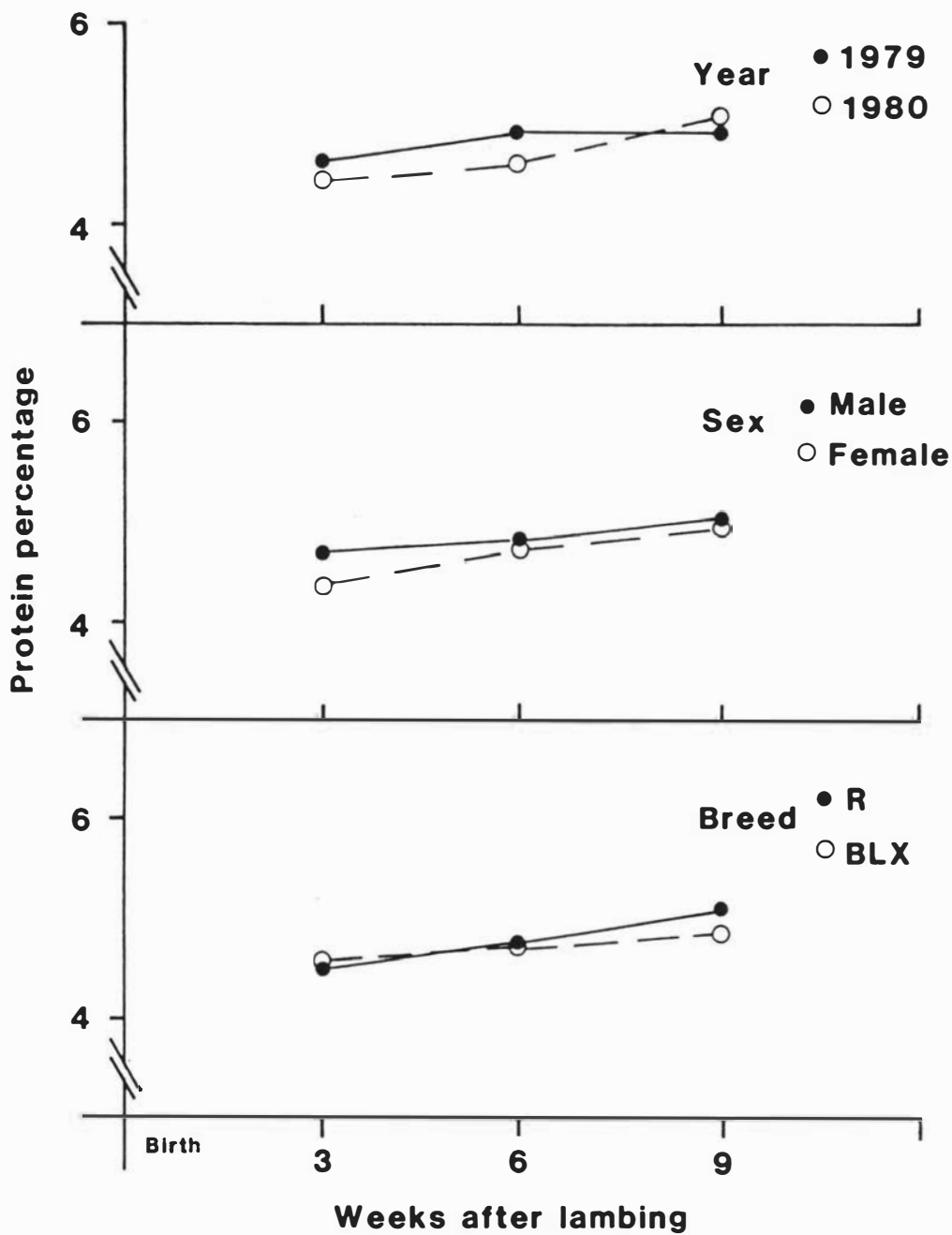


Table 4.67. Effects of breed and sex on the percentage milk protein of 16 hoggets recorded over 12 weeks at different stages of lactation.

Classification	Number	Weeks after lambing			
		3	6	9	12
Overall	16	4.53 \pm 0.15	4.53 \pm 0.07	5.17 \pm 0.08	5.34 \pm 0.14
<u>Breed</u>					
Romney	8	4.41 \pm 0.21	4.36 \pm 0.10	5.17 \pm 0.11	5.23 \pm 0.19
RLX	8	4.65 \pm 0.21	4.69 \pm 0.10	5.17 \pm 0.11	5.45 \pm 0.19
<u>Sex</u>					
Male	8	4.75 \pm 0.21	4.39 \pm 0.10	4.97 \pm 0.11	5.21 \pm 0.19
Female	8	4.31 \pm 0.21	4.66 \pm 0.10	5.37 \pm 0.11	5.47 \pm 0.19

Table 4.67 (continued)

Repeated-measurements analysis of variance

Source of variation	DF	Chi-square	Significance
Stages	3	20.6	***
Breed	1	0.8	NS
Sex	1	0.5	NS
Breed x sex	1	0.9	NS
Stages x breed	3	5.2	NS
Stages x sex	3	6.5	NS
Stages x breed x sex	3	2.3	NS

Number of observations per stage - 16

Table 4.68. Effects of flock, breed, year and sex on the percentage of milk protein at different stages of lactation for two-year-old ewes.

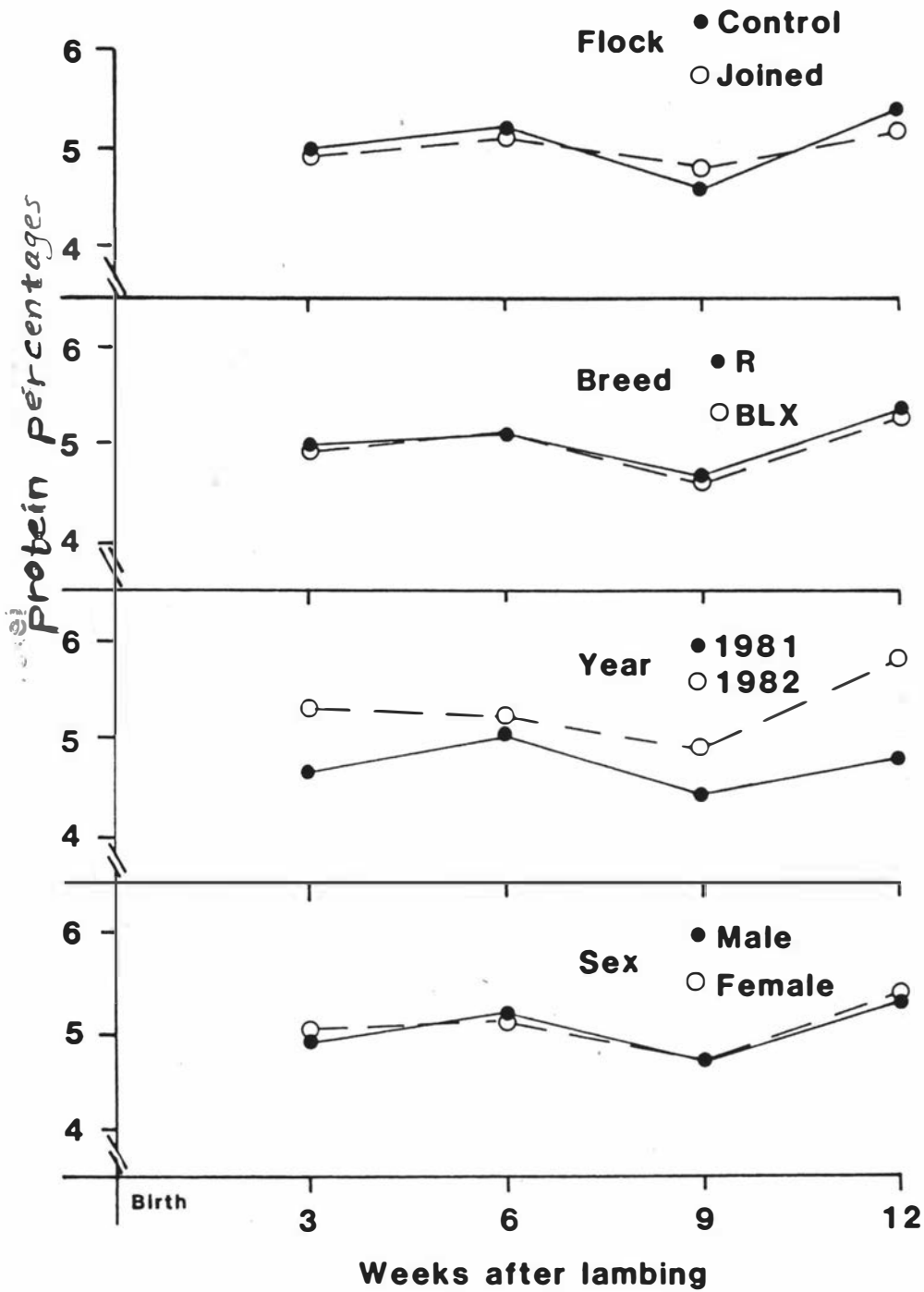
Classification	Number	Weeks after lambing			
		3	6	9	12
Overall	61	4.96 \pm 0.1	5.13 \pm 0.1	4.68 \pm 0.1	5.33 \pm 0.1
<u>Flock</u>					
Control	30	5.01 \pm 0.1	5.15 \pm 0.1	4.58 \pm 0.1	5.45 \pm 0.1
Joined	31	4.91 \pm 0.1	5.10 \pm 0.1	4.78 \pm 0.1	5.22 \pm 0.1
<u>Breed</u>					
Romney	30	5.01 \pm 0.1	5.13 \pm 0.1	4.71 \pm 0.1	5.36 \pm 0.1
BLX	31	4.91 \pm 0.1	5.13 \pm 0.1	4.64 \pm 0.1	5.30 \pm 0.1
<u>Year</u>					
1981	31	4.61 \pm 0.1	5.02 \pm 0.1	4.42 \pm 0.1	4.82 \pm 0.1
1982	30	5.31 \pm 0.1	5.24 \pm 0.1	4.94 \pm 0.1	5.85 \pm 0.1
<u>Sex</u>					
Male	29	4.88 \pm 0.1	5.16 \pm 0.1	4.66 \pm 0.1	5.26 \pm 0.1
Female	32	5.04 \pm 0.1	5.10 \pm 0.1	4.70 \pm 0.1	5.41 \pm 0.1

Table 4.68 (continued).

Repeated-measurements analysis of variance			
Source of variation	DF	Chi-square	Significance
Stages	3	46.7	***
Flock	1	0.6	NS
Breed	1	1.8	NS
Year	1	49.7	***
Sex	1	0.6	NS
Flock x breed	1	0.2	NS
Flock x year	1	2.8	NS
Flock x sex	1	1.0	NS
Breed x year	1	0.4	NS
Breed x sex	1	6.9	**
Year x sex	1	0.6	NS
Stages x flock	3	6.2	NS
Stages x breed	3	1.7	NS
Stages x year	3	16.8	***
Stages x sex	3	4.1	NS
Stages x flock x breed	3	3.4	NS
Stages x flock x year	3	1.0	NS
Stages x flock x sex	3	1.3	NS
Stages x breed x year	3	1.5	NS
Stages x breed x sex	3	0.4	NS
Stages x year x sex	3	1.6	NS

Number of observations per stage - 61

Figure 4-16 Milk protein percentages for 2 - year - old ewes



b. Milk fat

Similar analyses were carried out on the percentage of milk fat to that used for milk yield and milk protein and the same factors causing variation were studied.

Table 4.69 presents the means classified according to breed, year and sex of lamb from ewe hoggets.

The analysis showed that the stage of lactation had no significant effect on milk fat percentage (Figure 4.17). There was a significant effect of the year on percentage milk fat ($P < 0.01$), but breed and sex effects were not significant.

Similar analysis for the data of 16 hoggets was conducted and the estimated means are given in Table 4.70.

The results showed that milk fat percentage varied between stages ($P < 0.05$), but all other factors were not statistically significant.

Table 4.71 shows the mean values for fat percentage in 2-year-old ewes.

Stage of lactation influenced significantly the percentage milk fat ($P < 0.01$) as shown in Figure 4.18. The analysis also indicated that differences between years differed significantly and were not constant across the stages of lactation ($P < 0.001$). The effects of flock, breed and sex of lamb were not significant.

Table 4.69. Effects of breed, year and sex on the percentage milk fat at different stages of lactation for ewe hoggets.

Classification	Number	3	6	9
Overall	52	9.00 \pm 0.2	8.74 \pm 0.2	8.79 \pm 0.2
<u>Breed</u>				
Romney	25	8.91 \pm 0.3	8.64 \pm 0.3	9.06 \pm 0.3
BLX	27	9.08 \pm 0.2	8.84 \pm 0.3	8.53 \pm 0.3
<u>Year</u>				
1979	24	8.85 \pm 0.2	8.35 \pm 0.3	8.09 \pm 0.3
1980	28	9.15 \pm 0.2	9.13 \pm 0.3	9.49 \pm 0.3
<u>Sex</u>				
Male	26	9.12 \pm 0.2	8.89 \pm 0.3	9.08 \pm 0.3
Female	26	8.97 \pm 0.2	8.59 \pm 0.3	8.50 \pm 0.3

Table 4.69 (continued).

Repeated-measurements analysis of variance			
Source of variation	DF	Chi-square	Significance
Stages	2	3.2	NS
Breed	1	0.3	NS
Year	1	7.5	**
Sex	1	1.0	NS
Breed x year	1	2.8	NS
Breed x sex	1	1.3	NS
Year x sex	1	3.2	NS
Stages x breed	2	3.0	NS
Stages x year	2	3.0	NS
Stages x sex	2	0.3	NS
Stages x breed x year	2	1.8	NS
Stages x breed x sex	2	5.7	NS
Stages x year x sex	2	0.7	NS

Number of observations per stage - 52

Figure 4-17 Milk fat percentages for ewe hoggets

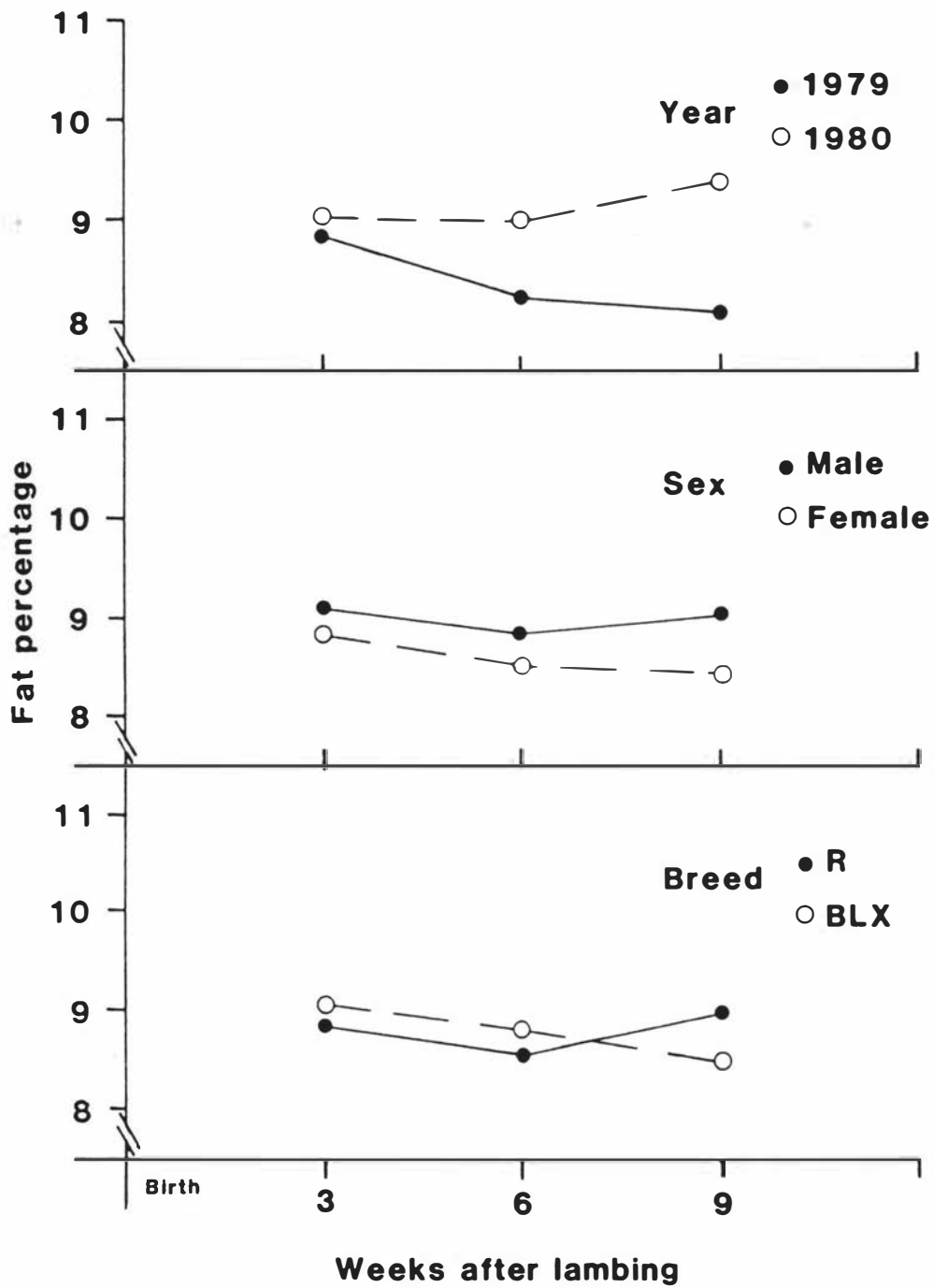


Table 4.70. Effects of breed and sex on the percentage milk fat of 16 hoggets recorded over 12 weeks at different stages of lactation.

Classification	Number	Weeks after lambing			
		3	6	9	12
Overall	16	9.8 ± 0.2	9.5 ± 0.3	9.2 ± 0.4	10.3 ± 0.7
<u>Breed</u>					
Romney	8	9.4 ± 0.2	9.1 ± 0.5	9.1 ± 0.6	10.0 ± 1.0
BLX	8	10.2 ± 0.2	9.9 ± 0.5	9.4 ± 0.6	10.6 ± 1.0
<u>Sex</u>					
Male	8	9.1 ± 0.2	9.3 ± 0.5	8.9 ± 0.6	10.8 ± 1.0
Female	8	10.4 ± 0.2	9.7 ± 0.5	9.6 ± 0.6	9.9 ± 1.0

Table 4.70 (continued).

Repeated-measurements analysis of variance			
Source of variation	DF	Chi-square	Significance
Stages	3	7.9	*
Breed	1	0.4	NS
Sex	1	0.4	NS
Breed x sex	1	0.4	NS
Stages x breed	3	1.5	NS
Stages x sex	3	2.4	NS
Stages x breed x sex	3	1.1	NS

Number of observations per stage - 16

Table 4.71. Effects of flock, breed, year and sex on the percentage of milk fat at different stages of lactation for two-year-old ewes.

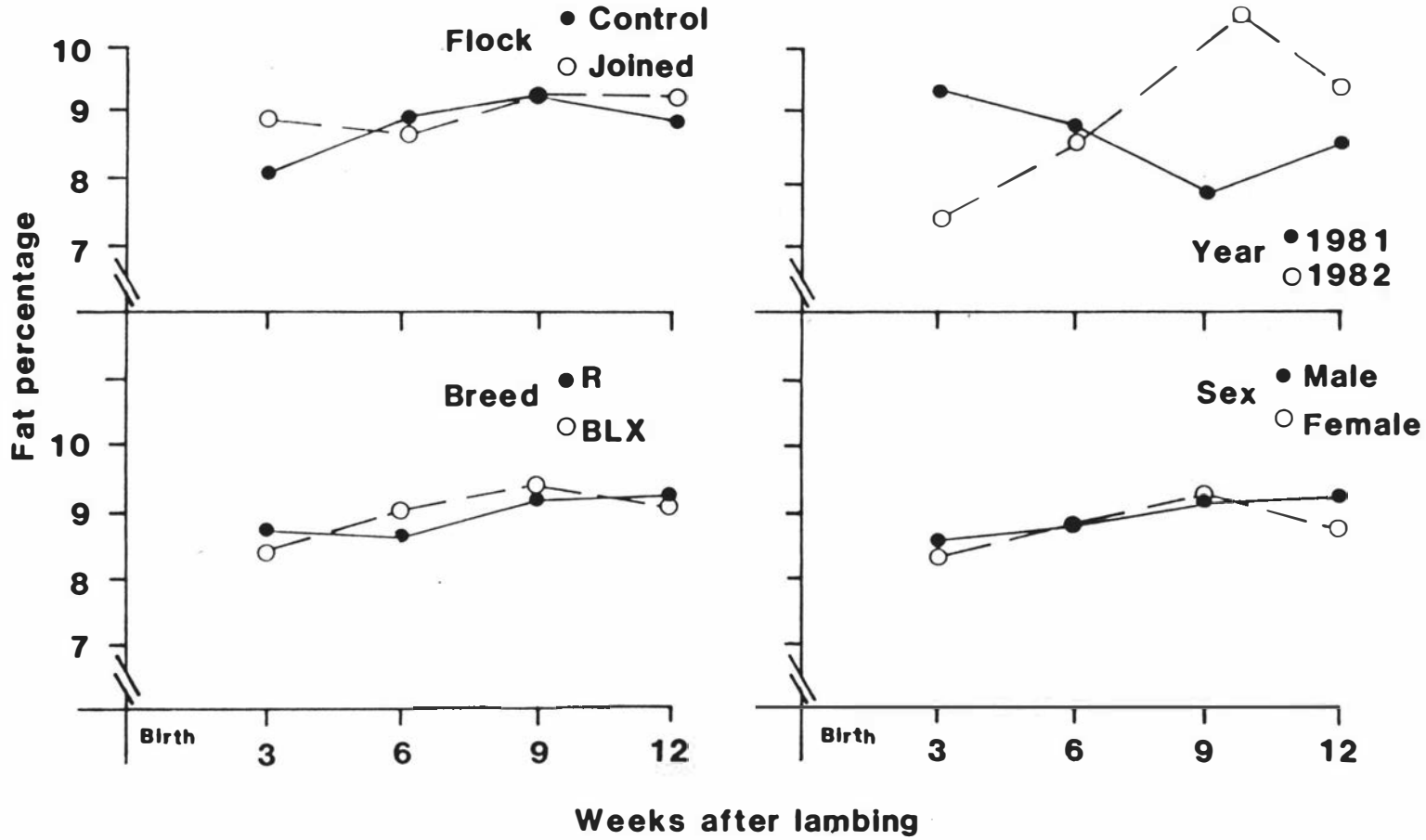
Classification	Number	Weeks after lambing			
		3	6	9	12
Overall	61	8.48 \pm 0.2	8.79 \pm 0.2	9.28 \pm 0.2	9.13 \pm 0.2
<u>Flock</u>					
Control	30	8.08 \pm 0.3	8.89 \pm 0.3	9.27 \pm 0.2	8.95 \pm 0.2
Joined	31	8.88 \pm 0.3	8.70 \pm 0.3	9.29 \pm 0.2	9.31 \pm 0.2
<u>Breed</u>					
Romney	30	8.52 \pm 0.3	8.60 \pm 0.3	9.16 \pm 0.2	9.16 \pm 0.2
BLX	31	8.44 \pm 0.3	8.99 \pm 0.3	9.39 \pm 0.2	9.10 \pm 0.2
<u>Year</u>					
1981	31	9.44 \pm 0.3	8.90 \pm 0.3	7.90 \pm 0.2	8.66 \pm 0.2
1982	30	7.51 \pm 0.3	8.69 \pm 0.3	10.65 \pm 0.2	9.61 \pm 0.2
<u>Sex</u>					
Male	29	8.56 \pm 0.3	8.79 \pm 0.3	9.21 \pm 0.2	9.33 \pm 0.2
Female	32	8.39 \pm 0.3	8.80 \pm 0.3	9.34 \pm 0.2	8.93 \pm 0.2

Table 4.71 (continued).

Repeated-measurements analysis of variance			
Source of variation	DF	Chi-square	Significance
Stages	3	11.8	**
Flock	1	1.0	NS
Breed	1	0.4	NS
Year	1	3.2	NS
Sex	1	0.3	NS
Flock x breed	1	0.5	NS
Flock x year	1	0.2	NS
Flock x sex	1	1.0	NS
Breed x year	1	0.7	NS
Breed x sex	1	0.4	NS
Year x sex	1	0.7	NS
Stages x flock	3	4.5	NS
Stages x breed	3	1.5	NS
Stages x year	3	49.5	***
Stages x sex	3	1.9	NS
Stages x flock x breed	3	1.6	NS
Stages x flock x year	3	1.6	NS
Stages x flock x sex	3	5.8	NS
Stages x breed x year	3	2.7	NS
Stages x breed x sex	3	1.0	NS
Stages x year x sex	3	2.7	NS

Number of observations per stage - 61

Figure 4-18 Milk fat percentages for 2-year-old ewes



3.7 Lamb growth and milk production

a - Daily weight gains

Lambs from hoggets - data on the growth rate of these lambs are given in Table 4.72 and Figure 4.19. Differences in weight gain between stages of lactation were significant ($P < 0.01$). The difference due to the effect of the year was significant ($P < 0.001$), and there was also a significant stage-by-year interaction ($P < 0.001$). The effects of breed and sex of lamb were not significant.

Data from the group of 16 animals that were examined at 4 stages of lactation are presented in Table 4.73.

Stage of lactation was the only significant effect ($P < 0.001$).

Lambs from 2-year-old ewes - Table 4.74 and Figure 4.20 show the growth rates of these lambs from 2-year-old ewes.

There were significant differences between stages of lactation ($P < 0.001$). The results indicated that lambs of BLX ewes gained more weight than the lambs of Romneys ($P < 0.05$), but the main factors (flock, year, sex) were not significant. There was a significant flock-by-sex interaction ($P < 0.01$). The results also showed significant interaction effects between some factors, notably between flock and year ($P < 0.01$), breed-by-year ($P < 0.05$), breed-by-sex ($P < 0.05$) and stage of lactation.

Table 4.72. Effects of breed, year and sex on the weight gains (kg/day) of the lambs from ewe hoggets.

Classification	Number	Weeks after lambing		
		3	6	9
Overall	52	0.31 ± 0.01	0.18 ± 0.01	0.16 ± 0.01
<u>Breed</u>				
Romney	25	0.31 ± 0.01	0.18 ± 0.01	0.15 ± 0.01
BLX	27	0.31 ± 0.01	0.19 ± 0.01	0.16 ± 0.01
<u>Year</u>				
1979	24	0.33 ± 0.01	0.19 ± 0.01	0.21 ± 0.01
1980	28	0.29 ± 0.01	0.18 ± 0.01	0.11 ± 0.01
<u>Sex</u>				
Male	26	0.30 ± 0.01	0.18 ± 0.01	0.16 ± 0.01
Female	26	0.31 ± 0.01	0.19 ± 0.01	0.16 ± 0.01

Table 4.72 (continued).

Repeated-measurements analysis of variance			
Source of variation	DF	Chi-square	Significance
Stages	2	78.9	***
Breed	1	1.5	NS
Year	1	12.3	***
Sex	1	0.1	NS
Breed x year	1	0.9	NS
Breed x sex	1	0.0	NS
Year x sex	1	2.3	NS
Stages x breed	2	0.6	NS
Stages x year	2	15.6	***
Stages x sex	2	3.3	NS
Stages x breed x year	2	3.0	NS
Stages x breed x sex	2	0.2	NS
Stages x year x sex	2	0.4	NS

Number of observations per stage - 52

Figure 4-19 Daily weight gains (kg) in lambs from ewe hoggets (milking group only)

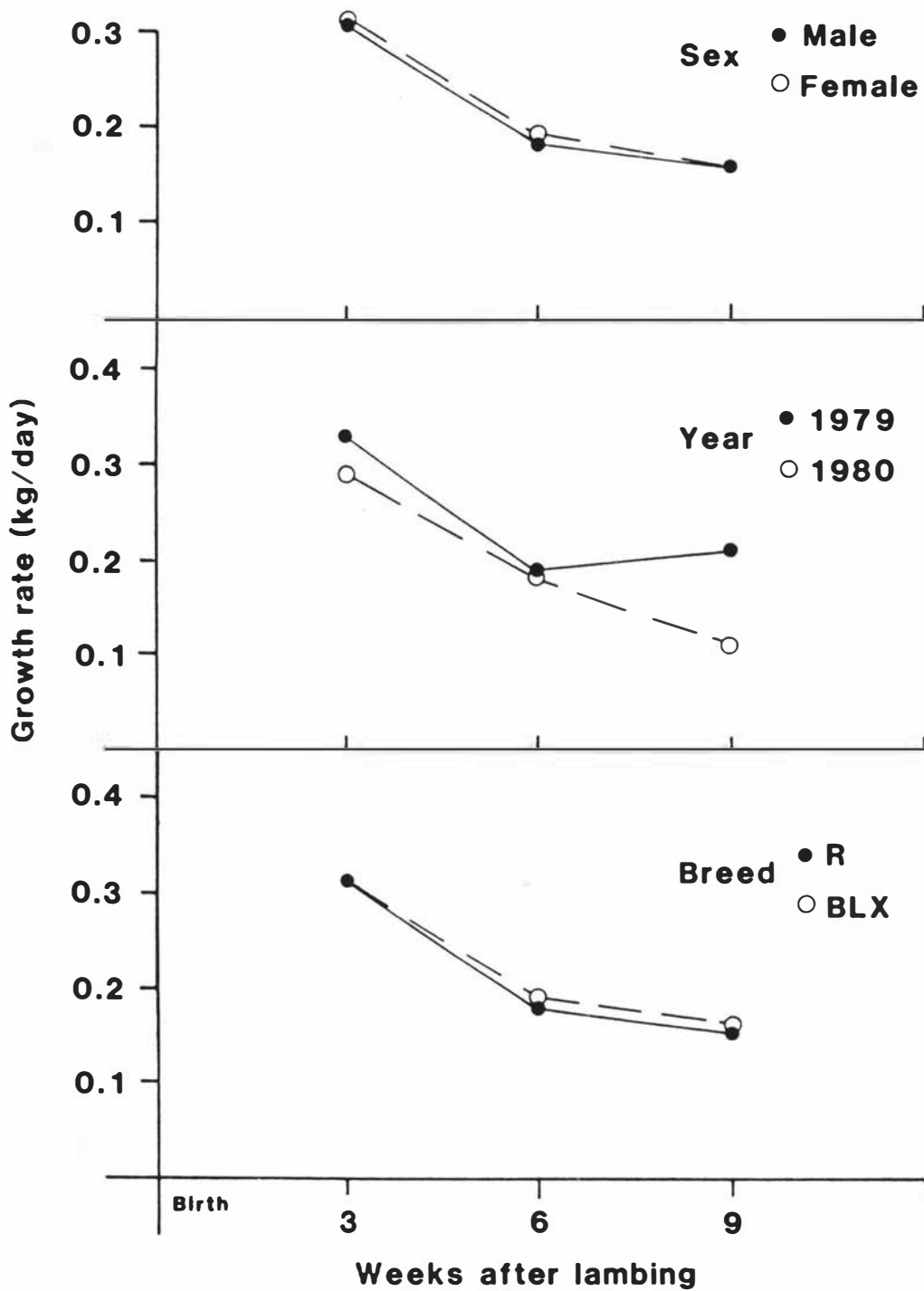


Table 4.73. Effects of breed and sex on the weight gains (kg/day) of the lambs from 16 hoggets.

Classification	Number	Weeks after lambing			
		3	6	9	12
Overall	16	0.32 ± 0.01	0.21 ± 0.01	0.14 ± 0.02	0.11 ± 0.02
<u>Breed</u>					
Romney	8	0.33 ± 0.02	0.22 ± 0.02	0.13 ± 0.03	0.09 ± 0.03
BLX	8	0.31 ± 0.02	0.20 ± 0.02	0.15 ± 0.03	0.13 ± 0.03
<u>Sex</u>					
Male	8	0.32 ± 0.02	0.21 ± 0.02	0.13 ± 0.03	0.13 ± 0.03
Female	8	0.31 ± 0.02	0.21 ± 0.02	0.15 ± 0.03	0.09 ± 0.03

Table 4.73 (continued).

Repeated-measurements analysis of variance			
Source of variation	DF	Chi-square	Significance
Stages	3	25.7	***
Breed	1	0.1	NS
Sex	1	0.0	NS
Breed x sex	1	1.7	NS
Stages x breed	3	4.3	NS
Stages x sex	3	1.1	NS
Stages x breed x sex	3	2.3	NS

Number of observations per stage - 16

Table 4.74. Effects of flock, breed, year and sex on the weight gains (kg/day) of the lambs (milking group) from two-year-old ewes.

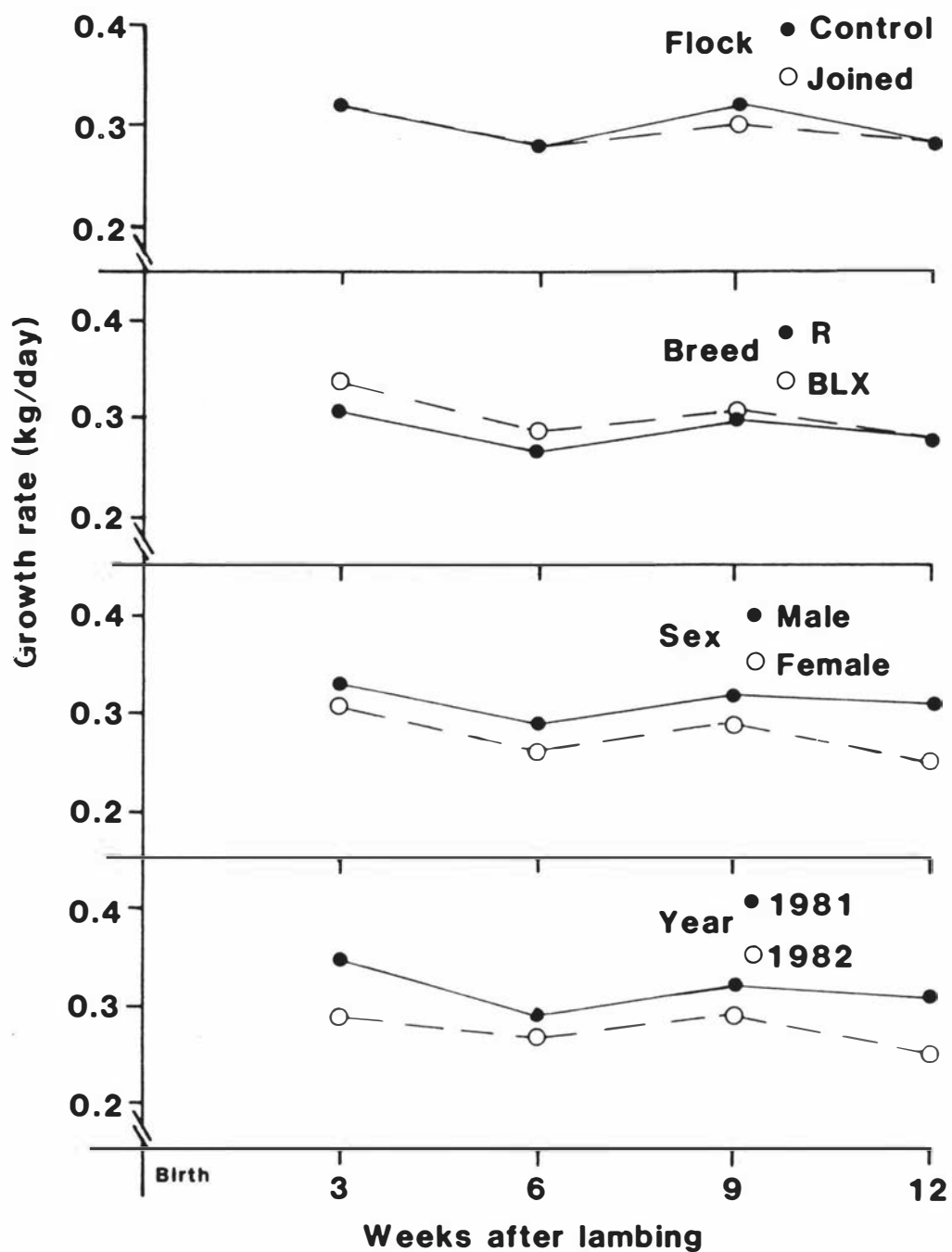
Classification	Number	Weeks after lambing			
		3	6	9	12
Overall	61	0.32 ± 0.01	0.28 ± 0.01	0.31 ± 0.01	0.28 ± 0.01
<u>Flock</u>					
Control	30	0.32 ± 0.01	0.28 ± 0.01	0.32 ± 0.01	0.28 ± 0.01
Joined	31	0.32 ± 0.01	0.28 ± 0.01	0.30 ± 0.01	0.28 ± 0.01
<u>Breed</u>					
Romney	30	0.30 ± 0.01	0.27 ± 0.01	0.30 ± 0.01	0.27 ± 0.02
BLX	31	0.33 ± 0.01	0.29 ± 0.01	0.31 ± 0.01	0.29 ± 0.02
<u>Sex</u>					
Male	29	0.33 ± 0.01	0.29 ± 0.01	0.33 ± 0.01	0.31 ± 0.01
Female	32	0.31 ± 0.02	0.26 ± 0.01	0.29 ± 0.02	0.25 ± 0.02
<u>Year</u>					
1981	31	0.35 ± 0.01	0.29 ± 0.01	0.32 ± 0.01	0.31 ± 0.01
1982	30	0.29 ± 0.02	0.27 ± 0.01	0.29 ± 0.02	0.25 ± 0.02

Table 4.74 (continued).

Repeated-measurements analysis of variance			
Source of variation	DF	Chi-square	Significance
Stages	3	37.2	***
Flock	1	2.6	NS
Breed	1	4.5	*
Year	1	2.9	NS
Sex	1	2.5	NS
Flock x breed	1	0.0	NS
Flock x year	1	0.4	NS
Flock x sex	1	7.5	**
Breed x year	1	0.4	NS
Breed x sex	1	0.1	NS
Year x sex	1	0.0	NS
Stages x flock	3	4.1	NS
Stages x breed	3	5.8	NS
Stages x year	3	6.8	NS
Stages x sex	3	3.1	NS
Stages x flock x breed	3	5.2	NS
Stages x flock x year	3	13.6	**
Stages x flock x sex	3	4.1	NS
Stages x breed x year	3	9.5	*
Stages x breed x sex	3	9.3	*
Stages x year x sex	3	4.6	NS

Number of observations per stage - 61

Figure 4-20 Daily weight gains (kg) in lambs from 2-year - old ewes (milking group only)



b - Correlation between milk production and lambs' growth

Hoggets

The correlation coefficient between milk yield and daily weight gains for lambs from Romney and BLX hoggets are presented in Table 4.75.

For milk yield, the correlation coefficients of 0.64 and 0.60 were significant at 4-6 weeks of lactation for the progeny of Romney ($P < 0.001$) and BLX ($P < 0.01$) hoggets.

For milk composition (percentage of milk protein and percentage of milk fat) and daily weight gain, the correlation values were not significant at any stage.

Data from the group of 16 animals that were weighed at 4 stages showed no significant correlation at any stage between milk yield, milk composition (protein and fat) and the daily weight gains (Table 4.76).

Two-year-old ewes

For 2-year-old ewes, similar analyses were carried out on the data for milk yield, milk composition with the daily weight gains of the lambs. Results are presented separately for lambs born to Romney and BLX ewes in Table 4.77.

Significant correlation coefficients of 0.43 ($P < 0.05$) and 0.52 ($P < 0.01$) were found between the milk yield and daily weight gains for lambs from Romney progeny at 4-6 and 7-9 weeks after lambing, respectively. The correlation coefficients between lambs' daily weight gains and milk composition were not significant at any stage.

Table 4.75. Correlation coefficients for lamb growth rate with milk yield and milk composition.
Data from hoggets at 3, 6 and 9 weeks after lambing.

Classification	Number	Milk yield			Milk protein (%)			Milk fat (%)		
		3	6	9	3	6	9	3	6	9
Romney	25	0.32	0.64 ***	0.22	0.22	0.07	-0.21	0.07	-0.22	-0.47
BLX	27	0.32	0.60 ***	0.34**	-0.11	-0.06	-0.06	0.25	0.11	0.09

Table 4.76. Correlation coefficients for lamb growth rate with milk yield and milk composition. Data from 16 hoggets at 3, 6, 9 and 12 weeks after lambing.

Classification	Breed	No.	Weeks			
			3	6	9	12
Milk yield	Romney	8	0.55	0.64	-0.78	0.38
	BLX	8	0.49	0.22	-0.17	0.00
Percentage milk protein	Romney	8	0.34	-0.21	0.04	-0.78
	BLX	8	-0.13	-0.00	-0.13	-0.23
Percentage milk fat	Romney	8	-0.79	-0.35	-0.35	0.16
	BLX	8	0.64	0.25	0.15	0.49

Table 4.77. Correlation coefficients for lamb growth rate with milk yield and milk composition. Data from two-year-old ewes at 3, 6, 9 and 12 weeks after lambing.

Classification	Breed	No.	Weeks			
			3	6	9	12
Milk yield	Romney	30	0.27	0.43 *	0.52 **	-0.05
	BLX	31	0.09	0.17	0.23	0.03
Percentage milk protein	Romney	30	-0.14	0.09	-0.45	-0.03
	BLX	31	-0.42	-0.17	0.22	0.12
Percentage milk fat	Romney	30	0.08	0.10	-0.20	0.01
	BLX	31	0.03	-0.13	0.04	-0.13

CHAPTER FIVE

DISCUSSION AND CONCLUSIONS

I. PRODUCTIVE PERFORMANCE

1. Liveweight Growth

The mean liveweight of the hoggets at the time of joining was 37 kg. To achieve good levels of production ewe hoggets and especially those to be saved as replacements for the breeding flock need to reach satisfactory target weights by certain ages and Craig (1982) has suggested that they should be of at least 35 kg by 1 May. Similar recommendations by Ministry of Agriculture and Fisheries (Dalton, 1981) suggest 33-36 kg by early April. Among the present hoggets at least 70% exceeded these 35 kg minimum target weights at the time of joining.

The BLX hoggets were consistently heavier than the Romneys and other workers have also noted the superiority in weight of first-cross animals over Romney (eg. Hight et al., 1973; McMillan, 1981). This difference between the genotypes carried over until the end of the experiment (Table 4.14). Likewise Coop and Clark (1965) have noted that Border-Romney ewes were heavier than Romneys throughout the whole of their lives.

The Control and Joined flocks of hoggets had similar liveweights from the time of joining through until September. At about this time the Joined animals on average gained more weight than the Controls (Table 4.3). This increase in liveweight gain was owing to the increase in weight of uterine contents after the third month of gestation. In the second year the hoggets were about 4 kg heavier than the first crop at the time of joining and showed the influence of better feeding and possibly management. The differential weight increase between the two flocks was also evident with those in the late stages of pregnancy.

Significant variation existed in the liveweight at first oestrus among the groups (Table 4.2). Hoggets which exhibited oestrus tended to be heavier than those which did not during the 28 days' mating period. These results support those reviewed by Dyrmondsson (1973, 1981, 1983) and McMillan (1981). Hoggets which showed oestrus, perhaps were more mature than those which ultimately proved barren (Quirke, 1978). Several studies (Ch'ang and Rae, 1970; Hight et al., 1973) have reported a high correlation between liveweight in September and that in the following March in New Zealand Romneys. Pre-mating liveweight was also

positively correlated with the number of hogget oestruses (Ch'ang and Rae, 1972). However, with Icelandic sheep Quirke (1978) has noted that when hoggets of light weight were excluded at weaning then there was an absence of any clear relationship between body weight and the time of onset of oestrus, and this is a similar finding to that of Keane (1974) studying Suffolk x Galway hoggets in Ireland.

At weaning time (end of December) hoggets which had lambed averaged 47 kg and were 2-4 kg lighter than the animals in the other groups. Recommendations of the Ministry of Agriculture and Fisheries (Dalton, 1981) suggest that hoggets would be about 40-45 kg at the time of weaning of their lambs and to achieve a satisfactory pre-mating weight of 50 kg, the ewes would then need to grow at the rate of about 150 g/day. Applying this daily gain target to our ewes then a pre-mating weight of 55 kg should have been achieved. This was not accomplished and it highlights the significance of summer feeding to get weight gain in ewes, and alludes to the problem of allocating the available feed between different classes of competing animals on the sheep farm.

By the time of joining the following March, ewes which had weaned a lamb were the lightest and were 5 kg less than those which had lost a lamb as a hogget. Undoubtedly the stress of lactation had an important effect on loss of liveweight and its regain. McMillan (1981) found that ewes which weaned their lambs early at 8 weeks gained approximately 2 kg more than unweaned ewes during the next 3 weeks (when late weaning occurred). He also found that early-weaned hoggets gained significantly less than cyclic hoggets which did not get pregnant. Thus it is important to keep the lactation period to a minimum when early breeding is adopted.

The differences in liveweight arising from hogget breeding which occurred in both crops of animals were continued until weaning the following year. The 2-year-old ewes that lambed for the second time were still the lightest among the groups, but the differences had declined to about 1-2 kg between the primi- and multi-parturient ewes. These differences were lower than noted by McMillan and McDonald (1983) who found about 5 kg differences in pasture-fed 2-year-old ewes at weaning time. Environmental conditions affecting the feed supply between these two studies would markedly influence the liveweights obtained at weaning. Thus when feed supply and management were not

limiting, liveweight differences arising from hogget breeding would not be large and unlikely to be carried over into the next year as was found by Southam et al. (1971), Tyrrell (1976) and Ponzoni et al. (1979) following supplementary feeding. To avoid such problems then a critical factor in the adoption of successful hogget breeding is to be able to grow the feed necessary to achieve good 2-tooth joining weight.

2. Reproductive Characteristics

a. Oestrus

Hoggets: Even though a restricted mating period was adopted, a high 83% of the animals showed oestrus, which was higher than in most other studies. The length of the joining period and the time within the breeding season when the rams and hoggets are together needs to be considered when comparing reports on the incidence of oestrus in hoggets. In this work the joining period lasted 28 days and each year the same date was chosen for ram introduction. Maintenance of the same length of joining but supposedly introducing the entire rams one week earlier showed that 74% of the animals would have been mated; a delay in the joining of the entire rams by one week would have resulted in 71% of the hoggets being marked. Thus the time chosen for joining the entire rams with the hoggets seemed optimal for achieving the maximum pregnancy rate.

The mean liveweights of the groups of hoggets which reached puberty during the joining period were about 1-3 kg more than those which failed to do so (Table 4.2). Recent studies reported by Moore and McMillan (1984) and which involved Romney, Coopworth and Perendale hoggets on hill country farms have indicated that most of the variation in reproductive performance between farms was due to differences in joining live-weight and the length of the joining period. They indicated that heavier flocks produced 3% more hoggets mating for each kilogram increase compared to lighter flocks, and also 2% more matings per day increase in the joining period. As well, in the present study slightly more BLX animals were in oestrus than Romneys (85.5% v 79.2%, NS) but the crossbreds were also slightly heavier.

Comparison of the Control and Joined flocks showed that 88% v 80% of the animals were in oestrus ($P < 0.05\%$). This result is somewhat unexpected since the animals were chosen at random and their joining or

early May liveweights were the same, and similar ram/ewe ratios were used. However, as the animals had to be run in several paddocks of different sizes to allow similar feed intakes to be achieved, then paddock size and pasture characteristic might be possible causes of the differences in occurrence of heat. In the present work the paddocks varied from less than 0.4 ha of even contour for the Control flock, to more than 1.4 ha of partly uneven contour for the Joined flock. For the latter it seems possible that loss of visual contact between ewes and rams could lead to a lower proportion of ewes mated than in the Control flock. Allison and Davis (1976b) have also noted that an increase in paddock size reduced the percentage of 2-tooths and mixed-age ewes which were located by rams. Further, the same authors (1976a) reported that there was some indication that the shape and topography of mating paddocks may be more important than absolute area in regard to mating efficiency.

Although the design of this study did not allow the accurate dating of first oestrus and the number of oestrous cycles, it was clear that peak activity occurred in mid- to late May and less animals were in heat in June; activity completely ceased by the beginning of July. This was in accord with the results of Hight et al. (1973) and McMillan (1981).

Two-year-old ewes: In only the first year was it possible to record accurately the start of the breeding season. These ewes were initially with teaser rams (8 weeks) and then were joined with entire rams on March 16 by which time, some ewes had shown heat (March 12). With the second crop of 2-tooth ewes the entire rams were not joined until March 22 nor were teasers run with the group.

One of the interesting findings was the highly significant difference in oestrus at "first cycle" between years (Table 4.18). This may suggest that the onset of breeding was influenced partly by the presence of teasers with the first crop of ewes. Between-year variation in the onset of oestrus has been reported by Tervit et al. (1977) and Knight (1980) and the latter has implicated photoperiodic variation to be a cause. Oldham (1978) has also suggested that previous nutrition can affect the onset of oestrus. While year effects must include a number of possible factors it is difficult to relate the observed difference to the variation in liveweight between years (a reflection of nutritional level) because at the time of joining with entire rams the second crop

of 2-year-old ewes were heavier than those in the previous year (Table 4.15).

One suggestion from the results is that farmers can increase the proportion of ewes mated early in the joining period by simply using 14-17 days of teasing with vasectomised rams just before joining.

b. Conception

Hoggets: The average conception rate to all services was 61% (Table 4.6). This result was lower than the conception rate of 81% found for similar genotypes reported by McMillan and McDonald (1983), but the higher conception in their study can be related partly to the longer duration of the joining period with entire rams. Approximately 1% more hoggets will lamb per day increase in joining (Moore and McMillan, 1984).

The superior conception rate of BLX hoggets over the Romney (75.8% v 43.0%, $P < 0.05$) was quite apparent. This result confirms earlier reports about the increased conception of cross-bred hoggets compared to straight-bred animals (eg. Dyrmondsson, 1973, 1981, 1983; Allison et al., 1975; McMillan and McDonald, 1983; Moore and McMillan, 1984).

One of the interesting results observed was that the pregnancy rate for hoggets marked by one ram was lower than for those marked by more than one ram. The greater the number of rams mating with a ewe, the lower was the probability of that ewe 'returning' in the next cycle and the greater the probability of her lambing. These results agree with earlier findings given by Knight and Lindsay (1973) and Allison et al. (1975). Failure of insemination in hoggets marked by harnessed rams can be a factor in low fertility rates (Allison et al., 1975). Quirke (1978) suggested that perhaps the relationship between oestrus and the time of ovulation is unfavourable, or that conditions within the reproductive tract of the hoggets are suboptimal for fertilisation, and subsequent ovum development or, indeed, that the ova produced by hoggets are inferior in quality to those of older ewes. Further information is required on the causes of conception failure in ewe hoggets. But it is notable that McMillan (1981) found that post-fertilization ovum survival of ewe hoggets was about half that of mature ewe ova.

Two-year-old ewes: The 95% of ewes lambing for all services (Table 4.19) was close to the results (96%) for similar genotypes reported by McMillan and McDonald (1983). This result was higher than has been reported for Romneys (82%) at Waihora by McCall and Hight (1981) and for the average of three breeds, Romney, Coopworth and Perendale (75%) studied on hill country farms by Moore et al. (1983). These differences between studies demonstrate the influence of environmental conditions on conception in these animals.

One of the interesting findings was the large difference between years in conception to first service based on all ewes joined (82% v 59%, $P < 0.001$). Such results demonstrate that the onset of breeding activity in 2-year-old ewes may be influenced partly by the presence of teaser rams with the first crop of ewes (1981). This difference in conception rate to first service cannot be explained by variation in liveweight of the ewes between years since the second crop of ewes was heavier at the time of joining (Table 4.15). Thus the presence of teasers having a stimulatory effect appears to be the major reason for the high occurrence of heat and for the high conception to first service, and about 80% of the ewes lambed within 3 weeks. However, Knight (1980) has noted that the full effect of increased oestrous activity after teasing was not reflected in the lambing pattern, because of a low conception rate in the first 14 days of joining. Further study on this aspect of breeding ewe stimulation would be justified.

c. Lambing percentage.

Overall the mean lambing percentages (number of lambs born per ewe present at mating) were 55.3% and 116% for the hoggets and 2-year-old ewes respectively.

The lambing percentage of the hoggets varied little between years (52% v 59%). This range was much less than the 5-57% calculated from the figures reported by Craig (1982) for Romney hoggets over eight years in the Waihora breeding flock. However, environmental conditions and joining liveweight should be taken into consideration when considering percentages between years or breeds. Furthermore in respect of the 2-year-old ewes there was variation between the two years (106% v 127%). This difference might be attributed to variation in joining liveweights between years since the second crop of ewes was heavier than the first crop and had more sets of twins.

More lambs were born to BLX sheep than to Romneys as hoggets (64% v 45%) or as 2-year-old ewes (124% v 106%). Several different studies confirm the ability of BLX to produce more lambs than from Romney animals (eg. Coop and Clark, 1965). In the present work there was a difference in the joining liveweights between the breeds and further the number of BLX females that produced twins was greater both in hoggets and in 2-year-old ewes.

The lambing percentage of the 2-year-old ewes was not detrimentally affected by the animals' previously having lambed as a hogget. In fact multi-parturient ewes were slightly higher (118% v 115%) than their primi-parturient contemporaries. This has also been noted with these same genotypes reported by McMillan and McDonald (1983). Evidence for a strong genetic correlation between lambing rate at one and two years of age has been noted by Eikje (1975). There are also some other observations that appear relevant, such as sexual precocity in ewe hoggets which may be predictive of reproductive performance in subsequent years, and that the most prolific ewes were those producing twins as hoggets (Collyer, 1981). Thus Ch'ang and Rae (1972) found that the body weights at 14 months of age and the number of oestrous cycles exhibited during the first autumn of life were genetically correlated with subsequent reproductive performance in Romney ewes. Therefore, these traits may be useful as indirect selection criteria for reproductive increase.

3. Lamb Production

a. Birthweight

Lambs from the Romney hoggets were about 0.4 kg heavier than those from the BLX hoggets (Table 4.53). Some of the variation in birth weight might be due to year effects and also to the relatively higher number of twins born to BLX hoggets. Comparing the same genotypes McMillan and McDonald (1983) found that differences in birth weight for lambs from BLX hoggets were 0.5 kg heavier than from Romneys. If allowance is made for the difference in twinning rate among the BLX animals in both studies then the mean birth weights appear similar. Furthermore, in respect of the 2-year-old ewes the breed of the ewe did not cause a difference in the birth weights of lambs (Table 4.54) and this result was also noted by McMillan and McDonald (1983).

As noted above the birth rank of lambs significantly affected the birth weight in both hoggets and 2-year-old ewes. Also year effects were apparent. However, such results were to be expected.

The sex of the lamb had no effect on the birth weight of the lambs from the hoggets, but from 2-year-old ewes male lambs were heavier ($P < 0.001$) than the females. Likewise a similar result occurred with lambs from older ewes (Hight and Jury, 1970; Dalton *et al.*, 1980). This sex effect arises because of differences in the make-up of female and male lambs and the influence of sex hormones on the animals' hormonal balance and metabolism (Bonsma, 1939). Schanbacher *et al.* (1980) concluded that testosterone appears to be the principal testicular hormone responsible for the superior performance of intact ram lambs.

In relation to commercial farming the non-castration of ram lambs is a practice that has been shown to offer economic advantages under some circumstances. However, non-castration of lambs from hoggets is not advocated because they will be born later than the main flock lambs. Furthermore, they will be of low weaning weight and probably give problems in regard to reaching a satisfactory slaughter weight if feed supply is restricted or if of low quality during the summer period. The risks associated with finishing male lambs from hoggets need to be considered in relation to any husbandry changes contemplated.

Birth weight was unaffected by "a previous lambing as a hogget". In fact, the birth weights of such lambs were slightly higher than those offspring from ewes parturient for the first time.

The present work indicates that the progeny from hoggets were generally lighter at birth than the offspring of 2-year-ewes. However in only one year (1981) was it possible to make the comparison and it should be remembered that the two ages of animals lambed about a month apart. Pasture conditions could not be regarded as the same and also Suffolk sires were used with the 2-year-old ewes and Southdowns with the hoggets. Notwithstanding these restrictions it is considered that the results were in good agreement with the literature reviewed by Dyrmondsson (1983). Dalton *et al.* (1980) with several breeds kept on hill country also has noted the increase in birth weight with dam age.

b. Daily growth rate to weaning

The lambs from BLX hoggets grew slightly faster than the lambs from Romneys (201 v 183 g/day, NS). A greater breed difference in the same direction between the lambs of the hoggets for the same genotypes (257 v 218 g/day, $P < 0.001$) was also reported by McMillan and McDonald (1983). The reasons for the faster growth rate of those lambs compared to animals in this study would include the lower number of twins born and reared and no doubt the different pasture conditions in the two investigations.

The finding that the progeny from BLX 2-year-old ewes (Table 4.60) grew faster than the progeny from Romneys is consistent with the results of Larsen (1971) and McMillan and McDonald (1983). The superior growth rate of crossbred lambs is generally attributed to greater growth potential and possibly also to increased milk extraction associated with heavier birth weight (Peart, 1967).

Daily growth rates of single lambs reared by hoggets (Table 4.58) were comparable at least with those of twins reared by 2-year-old ewes (Table 4.60). Generally, it seemed that hoggets can rear lambs at satisfactory growth rates, a result also indicated by McMillan and McDonald (1983). Furthermore, growth rate of lambs from 2-year-old ewes was unaffected by the mother having had a previous lambing (whether or not it weaned a lamb).

The low weaning weights for progeny born to hoggets were associated with early weaning at about 63 days (Table 4.55). One guiding consideration in deciding on the time for weaning should be the likely regain in liveweight of the hogget prior to the next mating season in contrast to allowing longer suckling and nursing of the lamb to obtain a higher weaning weight. The effect of feed utilization at the time of the year when the hoggets are to wean their lambs should also be considered. However, a severe maternal handicap was imposed on growth to the yearling stage of lambs born to one-year-old dams and few such animals themselves subsequently lambed at one year of age (McCall and Hight, 1981). It can be assumed from the results of low weaning weights that the retention as replacements of progeny born to hoggets would be detrimental to flock performance. Therefore in considering the breeding of hoggets care should be given to the breed of sire to be used. Most

hoggets that are bred should be mated by a meat-type sire such as the Southdown whose progeny can be finished at light weights. This system has more advantages than if straight-bred lambs are produced from "white-face" hoggets.

The weaning time was about 84 days for the progeny of the 2-year-old ewes (Table 4.57). The progeny from BLX were 2 Kg heavier at weaning than the lambs born to Romney ewes. These results agree with the earlier findings of Larsen (1971) and McMillan (1981) for the same genotypes and age, but the magnitude of the advantage of 2.2 to 4.4 Kg was less than found by Coop and Clark (1965).

Previously-lambled ewes achieved weaning weights of 0.5 Kg more for each lamb compared to those from primi-parturient 2-year-old ewes. These results demonstrate that breeding of ewe hoggets is possible and that the practice is not detrimental to 2-year-old ewes' productivity.

c. Weaning percentage

Hoggets and 2-year-old ewes had weaning percentages of 44 and 97% respectively.

The 44% of lambs weaned per ewe present at mating for hoggets was close to the 47% found by Moore et al. (1983) as an average for Romney, Coopworth and Perendale hoggets, but it was lower than the 58% reported by McMillan and McDonald (1983) for BLX and Romney sheep.

Differences due to the effect of the year of the study on weaning percentage were unimportant in hoggets. Craig (1982) has however reported a very wide variation during 8 years (4% - 43%) for the Waihora Romney hoggets. The variation between these studies can be explained by different environmental conditions, joining liveweight and duration of the mating period. In respect of the 2-year-old ewes the weaning percentage in each year was 86% v 109% ($P < 0.05$). Such between-year variation can be related to an increase in twinning rate especially in the 1982 crop of ewes and also to relatively high lamb mortality in the 1981 crop (Table 4.50).

The advantage in weaning percentage of 15% and 16% for crossbreds at the two ages is an important one. The superiority of the first cross

Border Leicester-Romney animals is widely accepted in New Zealand following the work of Coop and Clark (1965) and the many favourable farmer observations. While the magnitude of the difference was about the same, the factors responsible were not similar. Thus, for the hoggets to which few twins were born, the difference was caused largely by more BLX females breeding, whereas with the 2-year-old ewes the twinning percentage was the main factor between the two breed groups.

Appreciable proportions of the hoggets (167/282) and 2-year-old ewes (78/411) did not wean a lamb. The relative causes of the non-weaning inefficiency for the hoggets and 2-year-old ewes respectively were:-

1. failure to be mated, 32.3% and 1.3%;
2. failure to lamb after mating, 53.3% and 34.0%;
- and 3. failure to rear a lamb, 14.4% and 64.1%.

Failure to mate and failure to retain the pregnancy were more important in the hoggets. Among the animals that were mated but did not produce a lamb, the hoggets had less chance of being mated more than once than did the 2-year-old ewes. This was related to the difference in length of the joining period (28 days v 42 days) and to the later onset of heat in hoggets.

To improve conception rate McMillan (1981) has suggested that using active fertile rams, high ram-to-ewe ratios and small paddocks would be advantageous. In the present work it was considered that such limitations had been kept to a minimum. A further reduction in non-pregnant hoggets could have been accomplished by extending the joining period perhaps by one week, without seriously prolonging the lambing period.

4. Fleece Production

The hoggets were shorn a few days before the start of lambing. The difference between the Control and Joined flocks was small at the September shearing as it was at the following February and December shearings (Tables 4.12, 4.24). These results were not surprising since both flocks were grazed together most of the time and the joining live-weights were nearly the same.

Fleece weight did not vary significantly between groups of hoggets at September shearing (Table 4.13). The difference between groups ranged between 0.05 and 0.14 kg. Thus pregnancy per se did not have any significant effect on fleece weight. However, the Acyclic group had the lightest fleece weight compared to the other three groups, and this could be a reflection of the lightest liveweights (Table 4.2). September shearing of hoggets slightly preceded their lambing. A policy of shearing hoggets in May and then after lambing in November or early December followed by post-mating shearing of 2-tooth ewes in the following May should avoid the problem of increased abortion in the hogget. Also, casting of hoggets should not be a problem with this shearing pattern. However, post-natal lamb survival and growth might be affected in the hoggets not shorn until November.

Fleece weights in February for the 2-year-old ewes that had lambed as hoggets were about 0.16 kg ($P < 0.05$) lighter than the other groups (Table 4.25). As in the studies of Ponzoni et al. (1979) and McMillan and McDonald (1983) it is apparent that the lighter fleece weights of the lambed groups (at February) were associated with the combined effects of pregnancy and lactation. Ewes that lambed as hoggets but whose lambs died had fleece weights only slightly heavier (0.05 kg, NS). The 0.05 kg difference demonstrated the effect of pregnancy and sometimes part-lactation, because this group included all hoggets that had lambed and lost lambs at any time.

Carry-over effects of hogget lambing on fleece weight were not apparent the following December. Most other workers also have noted that the fleece weight of bred hoggets is usually lower than that of non-bred ones, but such differences rarely persist in later years (eg. Dyrmondsson, 1973; McMillan and McDonald, 1983)).

Differences in fleece weight due to cross-breeding were apparent at each of the three shearings ($P < 0.001$) and the combined fleece weights were 10.01 v 9.38 kg for the BLX and Romneys, respectively. Other workers have also shown the advantage of BLX animals over Romneys (eg. Coop and Clark, 1965; Hight and Jury, 1971; McMillan and McDonald, 1983). It must be emphasised that the cross-breds in the above studies were first generation individuals and therefore it might be expected that the full effects of hybrid vigour would be evident.

No measurements were made on the wool to examine the effect of pregnancy on fleece quality characteristics such as fibre diameter, staple length, or colour. However, Corbett (1979) with mature animals has shown that wool growth is reduced by about 30% during the last two months of gestation, or about 3-10% in terms of annual fleece production. Brown et al. (1966) concluded that about one-third of the reduction in wool growth by Merinos during pregnancy and lactation stems from a decrease in fibre volume. The decrease in fibre volume is due partly to a shorter length of staple and partly to a reduction in fibre diameter. The reduction in fibre diameter appears to be greater in ewes bearing and rearing twins compared with those with single lambs (12% v 6%; Turner et al., 1968).

A greater reduction in wool growth was found during pregnancy than during lactation (Brown et al., 1966; Rose, 1974; Reid, 1978). Other studies have indicated a larger effect of lactation than of pregnancy upon wool growth (Ray and Sidwell, 1964; Kennedy and Kennedy, 1968; Armstrong and O'Rourke, 1976). Further, the effect of pregnancy on wool growth was also greater at a higher than at a lower stocking rate (Corbett and Furnival, 1976).

In summary, it is evident that the effects of pregnancy and lactation on the wool quality in young ewes has not been established. Such information should be collected. It is quite clear from work with older ewes that measurable effects on wool quality are likely especially if the stress of lactation is great and feed supply is restricted. If such effects are important then wool quality of hoggets may be lowered sufficiently for it to be reflected in price.

II. BEHAVIOUR OF EWES AND LAMBS

1. Pre-partum Behaviour of the Ewe

The present results show that it was difficult to predict accurately the onset of parturition in the hoggets or the older ewes based on the occurrence of one or more of the behavioural criteria recorded. Even the occurrence of physical signs of impending parturition such as protrusion of the amniotic sac or the discharge of fluid did not allow the accurate prediction of the time of delivery (Tables 4.29, 4.30).

The signs of impending parturition that occurred appeared to be independent of breed and year effects in both hoggets and 2-year-old ewes. Further, lamb rank and flock effects were not apparent in the older animals.

There were 27% and 36% of pregnant hoggets and 2-year-old ewes, respectively, that showed an interest in a lamb and in the birth fluids of other ewes prior to lambing. This pre-lambing interest varied from a brief inspection of a lamb, to cleaning and sometimes even allowing the lamb to suckle, and even attempting to adopt a lamb. However, ewes which showed interest in the lambs of other ewes can inhibit bonding between the mother and her lambs, and this could lead to errors in recording the correct parentage of lambs (Kilgour and Dalton, 1984).

Interest in newborn lambs may be increased by olfactory cues from the birth fluids surrounding the neonate. A recent study by Poindron and Le Neidre (1980) has indicated that the onset of maternal behavioural signs several days before parturition is likely to be due to hormonal changes in the ewe at that time.

To prevent lamb stealing, Kilgour and Dalton (1984) have suggested the following practices:-

1. Identify and remove ewes that steal lambs from the lambing mob.
2. Restrict general ewe mobility in the lambing area by central zig-zag temporary fencing.
3. Spread the ewes over a wide area.
4. Form flocks of ewes with a spread of lambing dates.

On most commercial farms there would be difficulties in applying some or all of these suggestions. They are not without additional costs, as more labour and time is needed to implement them. Such costs in relation to the estimated reduction in lamb stealing needs careful consideration.

Near the time of birth, most of the hoggets and 2-year-old ewes try to move out of the flock and lamb in relative isolation. Most of these animals try to select sites near fence lines or corners of the paddock and few lamb in the middle of the paddock. It was also noticed that even after unlambd ewes were drafted-off to a new paddock, they then moved to favoured areas for lambing. These positions were favoured in consecutive years for both hoggets and 2-year-old ewes. The reasons why ewes select the same areas for lambing in the paddock are unclear. The ewe usually remains at this site, licking the ground and pawing it, and often a hollow may be scraped out.

Knowledge of the lambing site can be very useful. Thus, lambs born dead will be at the lambing site and if the placental membranes have not been eaten, they can be examined to determine the number of lambs born to the ewe (Kilgour, 1982). Kilgour and Dalton (1984) found that there were breed differences in the average time spent at the birth site and that young ewes such as 2-year-olds that had not lambed as yearlings spent more time at the birth site than older ewes that had lambed more often. In the present study, the duration of time spent on the lambing site was not recorded.

2. Parturition

Lambing during daylight hours for hoggets and 2-year-old ewes occurred at random (Figure 4.6), as it did in the studies of Arnold and Morgan (1975) and Owens et al. (1980) using different breeds and ages.

a. Length of labour

The comparison between hoggets and 2-year-old ewes is confounded by different seasons and different animals used in each year. The results show that hoggets had a shorter length of labour than the 2-year-old ewes (42 v 69 min). Arnold and Morgan (1975) also noted that most ewes were in labour for less than 1 h and very few more than 2 h.

The effect of birth rank on length of labour for hoggets was unimportant (Table 4.36). In the 2-year-old ewes the duration of labour for ewes delivering single lambs was significantly ($P < 0.05$) greater than that for twins (Table 4.37). This difference may be explained partly by the high birth weight of lambs born to the first crop of 2-year-old ewes (1981) which led to a high number of ewes having difficulties during labour. Owens *et al.* (1980) reported different findings, and the duration of labour for Booroola Merino ewes having twins was greater than that for ewes having singles. Lees (1979), however, reported only small differences between the length of labour of ewes having singles and those having twin lambs.

The length of labour for the first-born of twins was longer than that for the second-born (Table 4.38), which is similar to the results of Holmes (1975), Arnold and Morgan (1975) and Owens *et al.* (1980). The reason for the rapid birth of the second lamb is probably due to the dilation of the cervix and birth canal in the ewe by the first-born lamb, which may facilitate delivery of the second lamb.

The effect of the year of the study on the duration of labour was important in both hoggets and 2-year-old ewes. These year differences could be explained by the alteration in environmental conditions that occurred being reflected in variation in birth weight.

The 2-year-old ewes that had lambed as hoggets showed no marked difference in length of labour compared to those pregnant for the first time.

b. Expulsion of the placenta

The interval from birth of the lamb to expulsion of the placenta was longer in the hoggets than in the 2-year-old ewes (Tables 4.40, 4.41). Generally the placenta was voided within 3-5 h of birth which is in agreement with the results of Sharafeldin *et al.* (1971), Arnold and Morgan (1975) and Holmes (1975). The greater time-interval in the hoggets may be explained by the early reduction in voluntary abdominal muscle contractions to a great extent during this period. Also, at this period the animals were occupied in grooming and cleaning the new-born lamb(s) and so did not appear concerned with the placenta being still attached to the ewe. Furthermore, when the expulsion of the

placenta eventually occurred, it was not associated with any sign of pain (Sharafeldin et al., 1971).

Placentaphagia rarely occurred in the hoggets or 2-year-old ewes (a total of 9 animals). No reasons for such behaviour can be advanced, but it may be associated with curiosity by the ewe. Holmes (1975) noted that when the placenta was voided all ewes nosed and licked it, and about a third at least ate a small portion of it.

3. Lamb Behaviour

a. Birth - standing interval

These results show that twin-born lambs of hoggets were quicker to stand than the single-born lambs (Table 4.42). However, the limitation of only a few twin lambs must be noted.

The mean interval from birth to standing for the progeny of 2-year-old ewes was nearly the same for single- and twin-born lambs (Table 4.43). These results were in accord with results reported by Arnold and Morgan (1975).

The progeny of the first crop of hoggets stood earlier on their feet than the second crop (12.4 v 19.4 min, $P < 0.01$). This observation may be associated with the differences in mean birth weight between years (3.86 v 4.01 kg) which could have been associated with differential lambing difficulties and thus affected the rate at which the lambs got on to their feet. A lamb born following a prolonged birth would seem less inclined to get on to its feet than one born quickly and without difficulty.

The mean interval from birth to standing for the lambs of hoggets and 2-year-old ewes was independent of breed and sex. Also environmental factors such as rainfall, air temperature and wind speed at the time of lambing have also not affected the interval from birth to drinking (Arnold and Morgan, 1975). Thus it appears that factors which mainly cause variation in the speed of the lamb getting to its feet and probably also drinking will be associated mainly with vigour of the lamb and ease of parturition.

b. Standing - sucking interval

The progeny of the Romney hoggets took a longer time than the BLX to first attempt to suck from the teat (Table 4.44). Such a difference was not observed in the data of 2-year-old ewes (Table 4.45). The difference between breeds in lambs from hoggets might be due to some difficulties during lambing which affected the activity of the lamb, and also because of the low birth weight of some lambs. Arnold and Morgan (1975) reported that mean intervals from standing to sucking were unaffected by breed.

Single-born lambs of hoggets were quicker to start sucking than the twins (24.5 v 45.6 min, $P < 0.05$). In the progeny of 2-year-old ewes this difference between singles and twins was negligible (18.9 v 17.0 min, NS). Being slightly heavier in birth weight the single lambs of hoggets probably were more vigorous and hence found the teats more quickly than did twin lambs.

The significant difference ($P < 0.001$) between the years of the study was apparent in the data for lambs from hoggets but not with the 2-year-old ewes. However, the clear difference with the hoggets might be related to the number of twins observed in the second crop of animals which was double the number of the previous year. However, their birth weights were lower, which led to a longer time taken to suckle. Other environmental conditions (rainfall, air temperature, speed of wind etc.) might have had some effect.

Although the comparison between the mean intervals for the progeny of hoggets and 2-year-old ewes was confounded, the present results suggest that generally the progeny of hoggets took a greater time to start sucking from the mother than did lambs from 2-year-old ewes (51 v 33 min). This difference might be due to the heavier birth weights of the lambs from the 2-year-old ewes, which presumably would reflect a more vigorous or slightly more mature lamb.

4. Lamb Mortality

Progeny of hoggets

The incidence of death among lambs until the time of weaning

was 19.9%. This level of lamb mortality was somewhat lower than that found in other studies in New Zealand (Lewis, 1959, 23%; Hight *et al.*, 1975, 24%; Baker *et al.*, 1981, 28%; McMillan, 1983, 31%; McMillan and McDonald, 1983, 22%) but nevertheless shows that the problem is an important one with hoggets as it is in older-aged ewes.

Analysis of the data classified according to the cause of death (Table 4.48) showed that premature birth of non-viable lambs comprised 32% of the total mortality (6.4% of all lambs born). Such deaths may have occurred because of stress of mishandling when the hoggets were shorn a few days prior to lambing. While care was taken with the movement and shearing of the sheep, it is impossible to know just why the lambs died just before birth.

Dystocia accounted for 23% of the dead lambs or 4.5% of all lambs born to hoggets in the trial. Heavy birth weight of some lambs was an important factor related to this cause of mortality. McMillan (1983) found that dystocia is the most important cause of death among both light and heavy lambs and it accounted for 12% of lambs born.

The proportions of lambs dying of "Other causes" which included "starvation/exposure", "enclosed in the amniotic sac", "congenital defects", "accident" and "death from unknown causes", were 45% of dead lambs or 8% of lambs born. Starvation/exposure was the most important category for mortality and this had occurred within 3 days of birth. Most of the dead lambs recorded were born during the night.

The distribution of the lamb mortality according to birth weight indicated that more than 50% of dead lambs were 0.7 - 3.0 kg (Figure 4.11). These small new-born lambs, for whatever reasons, would be expected to have had lowered energy reserves per unit of body weight than larger lambs. Also they would have had the relative disadvantage of a large surface area and a high rate of heat loss per unit of body weight (Alexander, 1974).

Progeny of 2-year-old ewes

Mortality occurred in 16% of the lambs produced by these ewes, a figure which is about average for this age (McCutcheon *et al.*, 1981).

Most of the lamb deaths (77%) occurred during lambing or in the first few hours after birth. High birth weights among the dead lambs especially in the first crop of ewes seemed to be an important factor. In the first year the lambs were by Suffolk sires but Southdown rams were used the next year. While the breed of sire will influence the birth weight it is also likely that other environmental effects between years will have affected the level of mortality.

Dystocia as a cause of lamb death was more a problem with the Romney ewes than in the BLX (Table 4.50). Dalton et al. (1980) in a study of lamb losses for several breeds in New Zealand also noted that Romney (mixed-age) ewes had a high incidence of dystocia and suggested it could be related to a small pelvic inlet area. The low percentage of lamb deaths from dystocia for the BLX ewes might be due to that genotype producing lambs reputed to be shaped in a way that would reduce difficulties at birth, be delivered rapidly and therefore allow the lambs to be healthy, active, and develop quickly (McLachlan, 1973).

The effect of sex on the proportions of death due to dystocia is in general agreement with the results of Hight and Jury (1970), Dalton et al. (1980) and Duff (1981). The sex effect can be related to differences in birth weight with male lambs being on average 0.9 kg heavier.

Lamb deaths classified according to birth rank (Table 4.52) showed that dystocia was a major cause of mortality in singles (58% of total dead lambs) which was a conclusion also evident from the work of Joyce et al. (1976), Duff (1981) and McMillan (1983).

Behaviour and lamb mortality

The present results have shown that only a few hoggets and 2-year-old ewes deserted their lambs (Tables 4.46, 4.47). These desertions were only temporary and lasted up to a few hours. Assistance by a shepherd was provided in some cases so that the deserted lamb was accepted again by the mother. No losses among the lambs occurred due to temporary desertion, but the assistance given may have prevented impending loss from occurring. In other studies this cause of loss may also be small (3% - Shelley, 1970; 6% - Arnold and Morgan, 1975) but high losses of 20-30% have been noted at times (Winfield, 1970).

Most of the temporary desertions in the present study were related to prolonged labour, and not to pre-lambing maternal interest. This observation can be compared with that of Arnold and Morgan (1975) who found that "desertion" and "pre-lambing maternal interest" were the two forms of ewe behaviour which directly affected lamb mortality, but that neither was a major factor influencing lamb mortality. Further, Owens et al. (1980) noted that behaviour traits of the dam and neonate had no effect on the survival of the lamb to weaning. Thus it is concluded that lamb mortality due to poor maternal behaviour was negligible at least under the fairly intensive conditions of this study. However, further investigation is required under field conditions especially to determine the mortality among twins within a few days of birth and to establish if behavioural traits are implicated.

III. MILK PRODUCTION AND LAMB GROWTH

1. Milk Yield

It was not possible to specify just when peak milk production occurred in the ewes of this study, as the first milking was not conducted until about three weeks after lambing. However, at this stage the yield was higher than at the other times investigated (Tables 4.63, 4.65). It would seem likely that the milk production in these ewes increased during the first two weeks of lactation similarly to that reported for other lactating animals like the cow (Henderson and Pringle, 1982). Thus the results at the first recording probably indicate the peak or close to the peak levels of milk yield.

Milk production is influenced by the intake of the nutrients during pregnancy and especially during lactation (Barnicoat et al., 1956; Peart, 1967, 1968; Peart et al., 1975; Treacher, 1970; Robinson et al., 1974; Aboul-Naga et al., 1981). In this study ewes were fed on grass ad libitum with the amounts offered being varied according to the stage of pregnancy or lactation. No objective estimates were made, however, of the quantity offered to the animals nor of the residual amounts of pasture after grazing a paddock.

The BLX hoggets and 2-year-old ewes produced more milk than the comparable Romney animals (Tables 4.63, 4.65 and Figures 4.13, 4.14). Data on the milk yields of ewes under grazing conditions in New Zealand are limited and have not previously been reported for hoggets. Some of the advantages of crossing the Border Leicester with the Romney breed were demonstrated in the work of Coop and Drew (1963) which showed that the crossbred ewes (four-tooth) produced more milk than the Romney. Milk production of the ewes in their study was estimated by the technique of weighing the lambs before and after suckling.

Another important factor which affects the milk yield is the number of lambs being suckled. Several workers including Coop and Drew (1963), Geenty (1979, 1980), Torres-Hernandez and Hohenboken (1979), Doney et al. (1981) and Wohlt et al. (1981) have reported that ewes suckling single lambs produced less milk than those suckling twins. However, they did not distinguish between the potential of the ewe to produce milk and the potential of the lamb(s) to obtain it. In the present

experiments the full potential of the ewes for milk production may not have been reached because the ewes were suckling one lamb and were selected randomly on this basis. Furthermore, differences in the vigour of sucking by the different breeds of lamb may have influenced milk production by the ewes. No cross-fostering of lambs was attempted to estimate the influence of breed of lamb on the milk yield of the ewe. Many authors have concluded that the influence of lamb genotype must be considered when assessing the milk production of the ewe (Moore, 1966; Langlands, 1972; Peart et al., 1975).

Several other factors that might have influenced yield were examined. Thus the effect of the year of study on milk yield was unimportant in both hoggets and in the ewes. Further the milk yields of both ages of dam were not influenced by the sex of the sucking lamb. This confirms previous reports that milk yield was similar for mature ewes suckling either males or females (Torres-Hernandez and Hohenboken, 1980, and Wohlt et al., 1981). Finally the primi- and multi-parturient ewes had similar milk yields, even though the latter were about 4 kg lighter in liveweight.

2. Milk Composition

a. Milk protein

In common with the findings of several workers using older ewes (Barnicoat et al., 1949c; Scales, 1968; Peart et al., 1972; Geenty, 1974; Wohlt et al., 1981) the composition of the milk from the hoggets and 2-year-old ewes varied during the lactation period. The results showed that the concentration of milk protein increased significantly as lactation progressed, with the highest values at the end (Tables 4.66, 4.68). While this agrees with most other results published on older ewes (Barnicoat et al., 1949c; Geenty, 1974) there is some evidence that the milk protein of Dorset X Merino F₁ 2-year-old ewes has remained relatively constant during lactation (Wilson et al., 1971).

Breed differences in average percentage of milk protein for the hoggets and 2-year-old ewes were negligible. Romney and BLX hoggets and 2-year-old ewes had approximately the same-shaped curves (Figures 4.15, 4.16).

The variation in percentage milk protein between years was small for the milk from hoggets, but the differences were higher in respect of the 2-year-old ewes. There was an interaction between the stage of lactation and year for both hoggets and 2-year-old ewes. This interaction can be explained by the environmental differences between years of the study, that is in the good year nutrition enabled lactational performance to continue into late lactation whereas in the poor year, milking performance rapidly deteriorated.

The finding that the sex of the lamb did not affect the milk protein percentage in hoggets and 2-year-old ewes, was in agreement with earlier studies on other breeds and older ewes (Torres-Hernandez and Hohenboken, 1980; Wohlt et al., 1981).

Milk protein percentage was unaffected by a previous lactation, and both Control and Joined groups had similar percentages of milk protein.

b. Milk fat

There was marked variation in the percentage of fat in the milk from ewe hoggets (Table 4.69), and even more in that of the 2-year-old ewes (Table 4.71) during the different stages of lactation. Generally these results for milk fat were of the same magnitude as those reported by Barnicoat et al. (1949c, 1956) and Scales (1968) for older ewes. Possibly the different results might be due to the influence of the oxytocin technique with its associated greater removal of residual milk or it may be a reflection of the level of nutrition. Previous studies have shown that oxytocin hand-milking methods result in the removal of residual milk (McCance, 1959) which normally has a higher level of fat (Barnicoat et al., 1949b).

The results now reported are in good agreement with those from older animals and different breeds studied by several workers. Thus they reported no or only little variation between the breeds involved (Slen et al., 1963; Addleman et al., 1964; Scales, 1968; Geenty, 1979; Torres-Hernandez and Hohenboken, 1979). As well the sex of the lamb did not affect the milk fat percentage in hoggets and in the ewes, which confirms earlier results reported on older animals and different breeds by Wohlt et al. (1981). Further, the primi- and multi-parturient 2-year-old ewes had similar milk fat percentages.

3. Relationships Between Milk Production and Lamb Growth Rate

The present results show that there were significant correlations between milk yield and daily weight gains at 4-6 weeks of lactation (Table 4.75) but not at 3 weeks of lactation. This occurred in the progeny of both Romney and BLX hoggets. Barnicoat et al. (1949c) have suggested that correlation coefficients between milk production and lamb growth rate from birth to 3 weeks are in general often irregular because both ewes and lambs were in the process of settling down to the imposed conditions of the milking procedure, which might make the lambs unable to consume all the milk produced. In the period 4-6 weeks after parturition the lambs had become accustomed to the experimental procedure and were capable of drinking all of the milk produced. However, several workers (Barnicoat et al., 1949c, 1956; Slen et al., 1963; Scales, 1968; Geenty and Jagusch, 1974; Geenty, 1979; Torres-Hernandez and Hohenboken, 1980; Wohlt et al., 1981) have shown that the correlation between milk production and lamb growth was the highest at the start of lactation and declined as it progressed.

The low non-significant correlation between lamb growth rate and milk yield of the BLX 2-year-old ewes was unexpected (Table 4.77). However, some overseas workers (Mavrogenis and Economides, 1980; Mavrogenis et al., (1982) have also found that pre-weaning lamb growth was not always related to measures of ewe milk production. This leads to the suggestion that because lambs from the BLX animals were heavier in the first few weeks after birth than those from Romneys, this enabled them to eat more grass than did the progeny of the Romneys during the early lactation period.

Milk composition parameters were not significantly related to lamb growth for both the progeny from hoggets (Table 4.75) or 2-year-old ewes (Table 4.77). This result is in agreement with the findings of Barnicoat et al. (1949b, 1956), Slen et al. (1963), Geenty (1974), and Wohlt et al. (1981) on older ewes and different breeds. It therefore indicates that variation in milk composition was less important in determining lamb growth rate than was the total quantity of milk consumed.

V. BREEDING OF EWE HOGGETS IN COMMERCIAL PRACTICE

In the present study the natural breeding performance and productivity of ewe hoggets have been recorded in conjunction with non-bred contemporary hoggets and comparisons also made at the two-year age. These observations have included the occurrence of oestrus and conception and especially events associated with parturition, the lactation period and nursing of the offspring, and of major importance the females' rebreeding performance at two years of age.

Straight-bred Romneys and first cross Border Leicester-Romney hoggets were examined. The mean liveweights of the Romney and BLX hoggets at the time of joining were 34.9 and 38.5 kg and for the two-year-old ewes 44.7 and 50.2 kg, respectively. The ewes which lambed at 1 year of age compared to the non-bred animals were about 2 kg lighter, but this difference was gradually reduced over the subsequent year; while such liveweights are particularly high when compared with those of some commercial sheep in New Zealand, they are nevertheless considered typical for sheep on many farms in the North Island and quite satisfactory for Romneys kept on the Massey University farm.

The mating periods with entire rams of 28 days and 42 days resulted in 83% of the hoggets and 99% of the ewes being marked respectively. Hoggets which weaned a lamb came into oestrus in the following year almost at the same time as those not previously pregnant. Marked variation in the onset of oestrus in the ewes between years was probably due to the presence of "teaser" rams before the joining period.

Conception rate for all services per ewe joined, lambing percentage, and weaning percentages were higher for BLX than for Romney at both ages, but the differences between primi- and multi-parturient ewes were not significant.

During the lambing periods for the hoggets and 2-year-old ewes (which could not be studied together because of different natural mating times) observations of behavioural characteristics showed that for both ages a general pattern of behaviour of the ewe was established close to lambing. The behaviour traits at both ages were not affected by the breed, lamb rank or year of study, and among the 2-year-olds, whether they were primi- or multi-parturient. Thus the speed of lambing of the 2-year-olds was the same regardless of whether ^{or not} the ewe previously had been bred. The mean lengths of labour were 42 min and 69 min for the hoggets and 2-year-olds respectively,

while the interval from delivery of the lamb until it stood on its feet was about 16 min for both ages of female. The lambs from the hoggets took longer to start sucking the udder after getting to their feet than did the lambs from the ewes (35 v 18 min). Considering all parameters recorded it is evident that hoggets as managed in this study had a low incidence of lambing difficulty and were good mothers; losses among lambs due to poor maternal behaviour were negligible for both ages of dam. Overall, total lamb mortality between birth and weaning was 20% and 16% for hoggets and 2-year-old ewes respectively. The birthweights of lambs from Romney and BLX dams were 3.80 v 3.44 kg and 2-year-old ewes 4.26 v 4.53 kg, respectively.

The daily growth rates of the offspring of BLX were superior to those of Romneys (201 g v 193 g and 271 g v 249 g) for both hoggets and 2-year-old ewes respectively. The growth rates of lambs from 2-year-old ewes were generally higher than those for the progeny of hoggets and single lambs reared by hoggets were comparable at least with those of twins reared by animals one year older. Multi-parturient and primi-parturient ewes weaned lambs almost similar in weight.

Measurements of milk production suggested that peak yield occurred approximately 3 weeks post partum and then declined until weaning. The BLX dams at both ages produced more milk than did the Romneys and the limited data also suggested that the yield was more related to the lamb growth rates than was the variation in milk composition. Further studies on the relationships between the milking ability of the ewe and the growth of her offspring are required but the conclusion made from this trial is that hoggets can wean a lamb quite satisfactorily although the weaning weight is likely to be lower than that normally recorded for older-aged ewes.

It should be emphasized that in this study and as often carried out on commercial farms, the hoggets were mated to a meat-type sire, notably the Southdown. Other breeds of sire might be used, but could sometimes lead to lambing difficulties. It is a distinct possibility that in the present work low levels of lamb mortality among the hoggets were due to the crossbred offspring being of small size which would be partly due to the breed of sire chosen. Such crossbred lambs offer the possibility of early sale as slaughter lambs, even though they were born relatively late in the year. Had they been the offspring of a Romney ram (or other "white face" sire) then it is most likely that they would have presented more difficulty in "finishing" for slaughter or store-lambs sale.

A further possibility is that straight-bred progeny of hoggets might be available for future breeding purposes, thus meeting the objective of "reduction in the generation interval and increased rate of genetic improvement". Such a breeding policy has been attempted in the Waihora Romney Breeding Scheme (McCall and Hight, 1981). However as evident from the results of McCall and Hight (1981) and also the present study the lambs from 1-year-old dams are weaned at light weights and this penalty persists at later ages, the ewe having low pre-mating weight and reduced levels of performance. To overcome this handicap would require very high feeding levels and this may not be a feasible alternative in commercial practice.

Wool production from the BLX animals was higher than that for the Romneys at September shearing (yearling) and at the following February and December shearings. Yearling fleece weights did not vary significantly between groups of hoggets classified for their reproductive history (Acyclic, Mated by teaser rams, Lambled, Mated but not lambled). Fleece weights in February for those which had lambled as a hogget were about 0.16 kg lighter than the other groups. There was no carry-over effect of hogget lambing on fleece weight at the following December shear.

Different nutritional treatments were not imposed on the sheep in this investigation, but it would be of interest to examine the nutrition effects on wool yield. Reports in the literature do suggest that wool yield in hoggets which lambled will be depressed, but the magnitude is of the order of 0.2 - 0.4 kg over the year. It should be noted that in the present trial the animals were offered pasture ad libitum and as the wool yield reduction was not great then it is clear that the animals were well fed. It is possible that greater intakes of high-quality pasture might have been achieved although what effect would have been achieved remains conjectural.

Measurements of the lifetime productivity of the breeding ewe would have been a desirable objective but it was not practicable with the resources available. Thus in reaching conclusions from this study in relation to the practice of breeding from ewe hoggets, some allowance needs to be made for possible effects on productivity that might only become apparent at "mature age". Thus it might well be determined that while productivity of early-bred animals in comparison with non-bred hoggets was not affected within the 2-year stage, "carry-over effects" might later manifest as a relatively early decline in productivity. This might be reflected in reduced reproductive

performance or wool yield at say 5 years of age or relatively higher culling levels being necessary because of early failure of constitution. Thus, the extra value of early reproductive activity may well be decreased with depressed production at older ages. The magnitude of any depression in productivity still needs to be determined but some information in the literature suggests it cannot be great if adequate feeding is provided.

In summary, therefore, under the conditions of the trial it was evident that good levels of performance were achieved in the hoggets and as ewes in the following year. This has required sound management and good feeding levels so as to regain liveweight that is lost after lambing and especially during lactation. Reduction in the length of the lactation period as well as provision of sufficient feed prior to next mating appear important factors if successful breeding of hoggets is to be part of the farming system. Nevertheless breeding as a hogget will usually result in a transient slight decrease in fleece weight. In spite of this it is clear that there are sufficient benefits from early breeding of hoggets for the practice to be encouraged where management and husbandry are good.

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APPENDICES

APPENDIX 1. Lambing data.

Ewe Tag No: Date: Time:
 Birth Rank: Sex: Weight:
 Lamb Tag No:

BEHAVIOUR SIGNS:Behaviour signs pre-lambing:

1. Behavioural signs of parturition:

Restlessness and/or walking, isolation, seeking, vocalizing, licking herself, paws at ground, and showing pre-lambing maternal interest.

2. Physical signs of parturition:

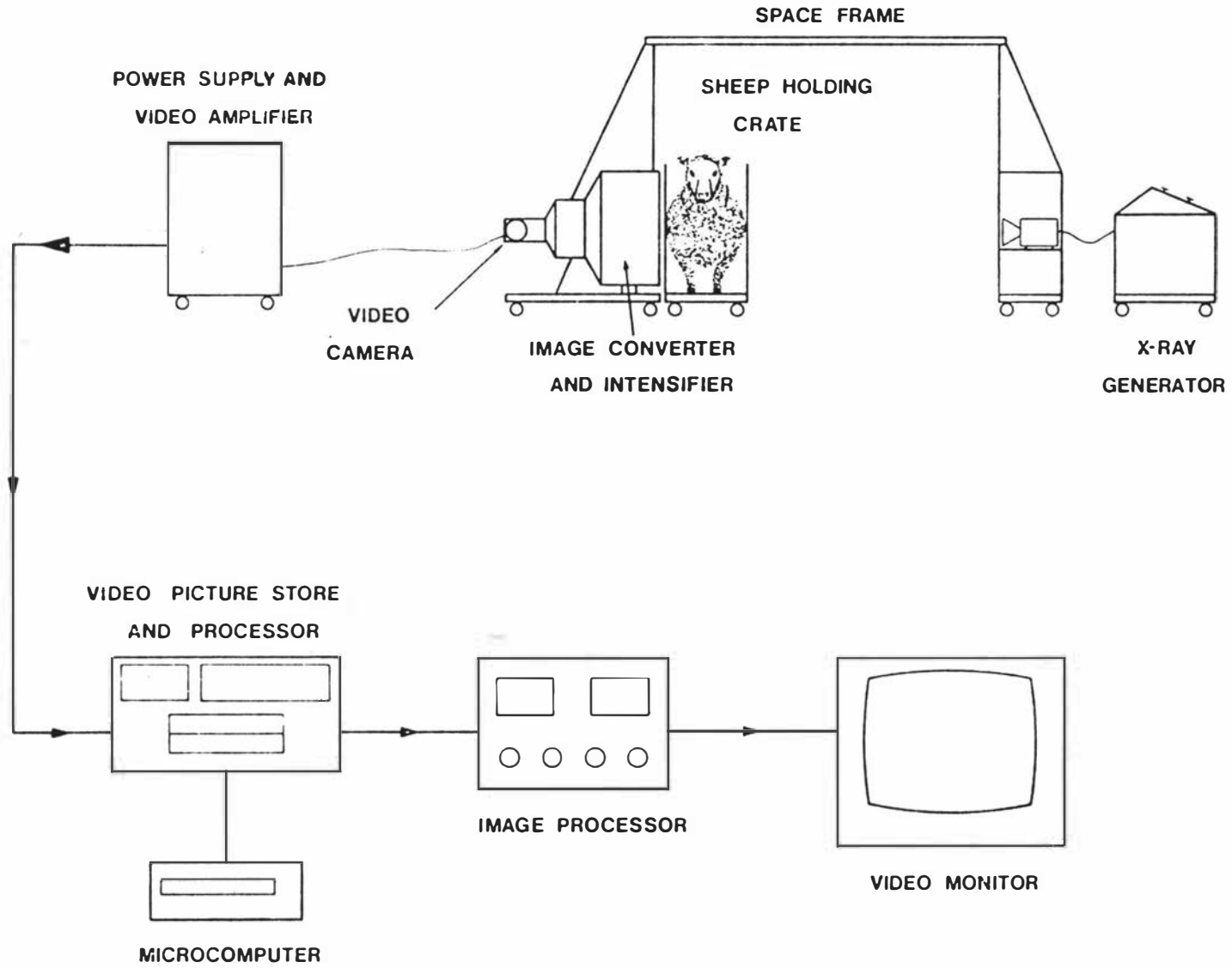
Discharge of the fluids or protrusion of the amniotic sac.

Ewe during lambing;

Lying	(Yes/No)	Stand up	(Yes/No)
Walking	(Yes/No)	Paws at ground	(Yes/No)
Licking herself	(Yes/No)	Vocalize	(Yes/No)
Distress call	(Yes/No)	Length of labour	()
Delivery	(Yes/No)		

Ewe after lambing:

The interval from birth to standing,	(Yes/No)
and from standing to drinking	(Yes/No)
The interval between the birth of the first and second of a twin pair	()
Ewe lying after birth for	(>2 min)
	(>3 min)
Ewe failing to stand still when lamb approaches udder	(Yes/No)
Ewe deserting its lamb	(Yes/No)
Time the placenta voided	()



Appendix 2. A diagram of the X-Ray machine.

APPENDIX 3. Pregnancy diagnosis in hoggets and two-year-old ewes.

When each animal was examined for pregnancy and the diagnosis made, two types of error appeared possible. These were:-

1. A ewe that was diagnosed as pregnant, might not lamb (false positive), and
2. A ewe diagnosed as not pregnant, might deliver a lamb (false negative).

Tables A1 and A2 show the results of pregnancy diagnoses made in the hoggets and 2-year-old ewes, respectively. Although comparison of all the various methods is not possible, it is evident that the diagnoses made in some ewes varied between the methods used.

The use of tugging records as a means of determining pregnancy showed that it was less successful with the hoggets than with 2-year-old ewes (77% v. 96%). Most of these errors were caused by false positive diagnoses, i.e. errors in barren ewes of which there were proportionally more among the hoggets. Few errors occurred in the animals whose records showed they returned to oestrus and therefore were classed as not pregnant. Tugging records also give an early indication of the mating performance of the flock, and allow prediction of the expected lambing period.

Visual assessment of pregnancy status was very accurate in both age groups of animals. However, it should be noted that the method was applied only a few days before lambing started and in some circumstances this is a restriction in the application of the method. The result showed that a few non-pregnant hoggets and ewes had been diagnosed as pregnant. All, except one, pregnant animals were diagnosed correctly.

The ultrasonic detection method was used on the hoggets only. The accuracy of this method was just above 80%. False positive diagnoses caused 19.2% error and negative diagnoses 15.4% error. The accuracy could probably have been higher if the operator had been practiced in using the machine before testing the ewe hoggets. The availability of a known pregnancy-state group of sheep to "calibrate" the operator might assist in improving the accuracy of the diagnosis made.

The false positive diagnoses can result from signals due to reflection of the ultrasound beam by the non-pregnant uterus filled with fluid because of oestrus (Thibault and Levasseur, 1974) or pyometra (Lindahl, 1969), or from a full bladder due to improper placement of the transducer. Lane and Lewis (1981) reported that early pregnancy was more easily detected in mature ewes than in ewe hoggets. The larger size of the gravid uterus may simply provide a more detectable target for the ultrasound beam early in gestation in larger mature ewes than in ewe hoggets.

Tables A2 and A3 show results using the X-Ray method for diagnosis of pregnancy in 2-year-old ewes in 1981.

The accuracy of pregnancy detection was 92%. Single and twin foetuses were correctly diagnosed in 92.5% and 89.5% of the ewes respectively. The percentage of false negative diagnoses might also have been reduced if the operator had had more experience and had spent more time in examining the video monitor. Subsequent studies carried out using the X-Ray equipment by the same operator has shown a slight improvement in the degree of accuracy achieved (Beach, unpublished data).

Improvements in the technique of ultrasonic foetal determination have recently been recorded by Fowler and Wilkins (1984). This has involved the use of real-time ultrasonic imaging and this method has resulted in an overall accuracy of diagnosis in early pregnancy (40-47 days) of 93%, with twin diagnosis being 85%. Increases in accuracy seem possible where a longer time is spent in examining the image and with experience gained by the operator. Real-time imaging is an improved ultrasonic technique on that which was previously being utilized in the present study.

Table A1. Pregnancy diagnosis in ewe hoggets.

Method and diagnosis		No. of animals examined	<u>No. of diagnoses</u>		Error rate (%)
			Correct	Incorrect	
Tupping records	Pregnant	199	137	62	31.2
	Not pregnant	83	81	2	2.4
Visual assessment	Pregnant	143	138	5	3.5
	Not pregnant	139	138	1	0.7
Ultrasonic detection	Pregnant	146	118	28	19.2
	Not pregnant	136	115	21	15.4

Table A2. Pregnancy diagnosis in two-year-old ewes.

Method and diagnosis		No. of animals examined	No. of diagnoses		Error rate (%)
			Correct	Incorrect	
Tupping records	Pregnant	401	384	17	4.2
	Not pregnant	10	10	0	0.0
Visual Assessment	Pregnant	387	384	3	0.8
	Not pregnant	24	24	0	0.0
X-Ray †	Pregnant	176	175	1	0.6
	Not-pregnant	31	16	15	48.8

† - animals in 1981 only.

Table A3. Diagnosis of pregnancy and foetal number in two-year-old ewes using X-Ray technique.

Diagnosis	Examined	No. of animals		Error rate (%)	Actual lambing records
		Diagnosed correctly	Diagnosed incorrectly		
Pregnant - single	159	147	12	7.5	159 †
Pregnant - twin	19	17	2	10.5	31
Not pregnant	31	16	15	48.4	17

† Two ewes that died during lambing each had a single lamb in utero.