# Lamb Rearing Performance in Highly Fecund Sheep

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2004

This thesis is presented in partial fulfillment of the requirements for the degree of Doctor of Philosophy at Massey University, Palmerston North, New Zealand

The Massey University Animal Ethics Committee has approved the studies involving animal manipulations

I have prepared this thesis and it is a record of my own work.

I took the photos of the sheep, unless otherwise specified.

# Abstract

This thesis investigates ewe and lamb behaviour, genetics and environmental effects to determine whether lamb rearing performance can be improved in highly fecund sheep. The studies were carried out under commercial pastoral farming conditions. High performing sheep farmers were surveyed to identify management and performance practices that differentiate farms with high and low lamb rearing success. Farmers agreed that mothering ability was the most important factor affecting lamb survival and considered lamb survival to be the most important trait affecting farm profit. The survey identified the Coopworth breed as the predominant breed of high lambing percentage flocks.

Heritability estimates were derived for lamb survival ($h^2$= 0.16), ewe maternal behaviour score ($h^2$= 0.05) and litter survival ($h^2$= 0.00) in a Coopworth flock that had been selected for improved maternal ability for nearly 30 years. Maternal genetic variation in the Coopworth flock was low for lamb and maternal traits and suggests that farmers must consider the environment and management techniques to improve lamb survival. A greater proportion of the variation in triplet survival was attributed to environmental effects than it was for twins, therefore triplets require more care.

Management and environmental factors investigated in this study affected ewe and lamb attachment behaviours in larger litters. A relationship was found between pregnant ewe physiology and maternal behaviour. Ewes that maintain body condition in late pregnancy and have lower plasma β-hydroxybutyrate levels were more receptive to the demands of their litter as these ewes had higher MBS. The effect of maternal nutrition in late pregnancy and at lambing was explored further. Feeding levels did not affect the majority of maternal behaviours investigated. However triplet lamb behaviour was affected by maternal nutrition in late pregnancy and lambs born to poorly fed ewes were less likely to stand, locate their dam's udder and follow their moving dam after separation at tagging. Triplet lamb survival was similar to twin lamb survival when pasture allowance was not restricted in late pregnancy.

Ewe behaviour was affected by breed, selection line and litter size. Ewes that high bleated less and showed less flocking behaviour, in the arena test and at tagging had greater lamb rearing performance at weaning. Ewes that were quick to contact their lambs after separation at tagging weaned greater lamb weights (weight weaned increased 10kg per ewe from MBS3 to MBS4). Lamb behaviour was not affected by breed and was not explained by birthweight. Lambs that stood and sucked from their dam within ten minutes from tagging had an improved chance of survival to weaning (survival increased 5-fold and 3-fold respectively). Lamb behaviour has a significant role in ewe-lamb attachment in large litters. In particular lamb bleating represents need and attracts the dam when separated. The lamb bleats more if its dam has a lower MBS and it will bleat more if it stands quickly. The dam will high bleat when she has lower MBS and cannot locate her lamb or litter.

Lamb rearing success for ewes with larger litters is determined by lamb behaviour and the lamb's interaction with its dam. Triplet lambs can achieve survival rates similar to twins, providing the maternal environment and lamb genetics support appropriate ewe-lamb attachment behaviours.

# Acknowledgements

I have really enjoyed the past three years and I have many people to thank for that. I am extremely grateful to my two Supervisors, Professor Hugh Blair and Professor Kevin Stafford. Thanks for your tremendous support, encouragement and "pearls of wisdom". I couldn't have asked for a better team of Supervisors.

I am also extremely grateful to Nicolas Lopez-Villalobos. Without Nicolas my stats knowledge wouldn't be what it is today. Nicolas taught me to question everything, don't accept 'anything' and "get to know your data first".

Very special thanks to all of the farmers that have contributed to this research project. Thanks to Bill, Simon and Pascale Carthew for allowing me to investigate their Coopworth flock in the 2000 lambing season. Thanks to Robin Hilson and Gary McLennan for giving me the opportunity to investigate Finn and Texel behaviour in the 2001 lambing season. Thanks to Graham Poole, Manager of Massey University's Keebles farm, for helping with 2002 trial work.

Thanks to Allain Scott for looking after us (postgrads). Thanks to Luc Doornheege (from the Netherlands) for working long hours in the 2001 lambing season. Thank you Barbara Gallagher and Elaine Patton (from Ireland) for helping with the arena behaviour tests. Thanks to Dean Burnham, Paul Kenyon and Steve Morris for allowing the behaviour investigation to be incorporated into the trial: "The feeding requirements of high fecundity ewes". Thanks to Trevor Cook, from Manawatu Vet Services. I would also like to thank Mike Hogan (IVABS) for managing the lamb post mortems.

A very special thank you to AGMARDT for personal financial support made available through a 3 year stipend. Thanks to IVABS and Clutha Vets for financial assistance. The research projects were jointly funded by WoolPro (Meat and Wool Innovation), Massey University Riverside Fund and IVABS.

To my husband, family and friends, thanks for your love and support.

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# Introduction

In New Zealand, many sheep breeders have selected and bred ewes for increased fecundity over the last two decades. Selection within existing breeds has been used to establish highly prolific flocks (Davis *et al*., 1987). Highly fecund breeds such as the Finnish Landrace and East Friesian were introduced in the 1990's with the objective of increasing flock fertility (Meadows, 1997).

Improved lambing percentage is the biggest contributor to higher profits on New Zealand sheep farms (Geenty, 1997). The national mean lambing percentage in 2002 was 124%, which was significantly greater than the 2001 season's record of 119% (Anon, 2002). Davis *et al.* (1983) reported that triplets replace singles as litter size increases above 1.7 lambs per ewe. The increased proportion of ewes having triplets is of concern to farmers and to industry as lamb mortality is assumed to be highest in triplets before 24 hours post-partum (Amer *et al*., 1999).

Lamb survivability is an increasing problem. Lamb losses of 30% have been recorded between pregnancy scanning and tailing (Anon, 2002; Aspin, 1997) and above a litter size of 2.3 lambs born per ewe lambing, farmers can expect a reduction in farm profitability (Amer *et al*., 1999). Twin and triplet born lambs have higher mortality rates than singles (Hall *et al*., 1988; Johnson *et al*., 1982; Hinch *et al*., 1983; Scales *et al*., 1986). Many studies emphasise the importance of lamb birth weight reporting lower survival to weaning in lambs weighing less than 3kg at birth (Dalton *et al*., 1980; Johnson *et al*., 1982; Hight and Jury, 1970; Nowak and Lindsay, 1992). But overall, the relationship between lambing rate and lamb survival is poorly understood in highly fecund ewes.

Most lamb deaths occur in the first two days from birth and adequate maternal care is required to minimise losses and minimise the effects of detrimental environmental factors (Poindron *et al*., 1984). However the proper expression of adequate maternal behaviour is made more difficult by modern livestock systems which increase fecundity and thus increased demands upon the mothering ability of ewes (Chenoweth and Landaeta-Hernandez, 1998).

Farmers and scientists are searching for ways to improve lamb-rearing ability in highly fecund sheep, as current lamb losses are not acceptable from a production and animal welfare perspective.

The objective of this thesis is:

*Can we improve lamb rearing performance in highly fecund sheep?*

This thesis has taken a holistic and applied approach to investigating the genetics, behaviour and management of the ewe-lamb relationship and investigated the integration of these factors under commercial pastoral farming conditions. The relevant literature has been reviewed and trials have been designed to investigate the following questions:

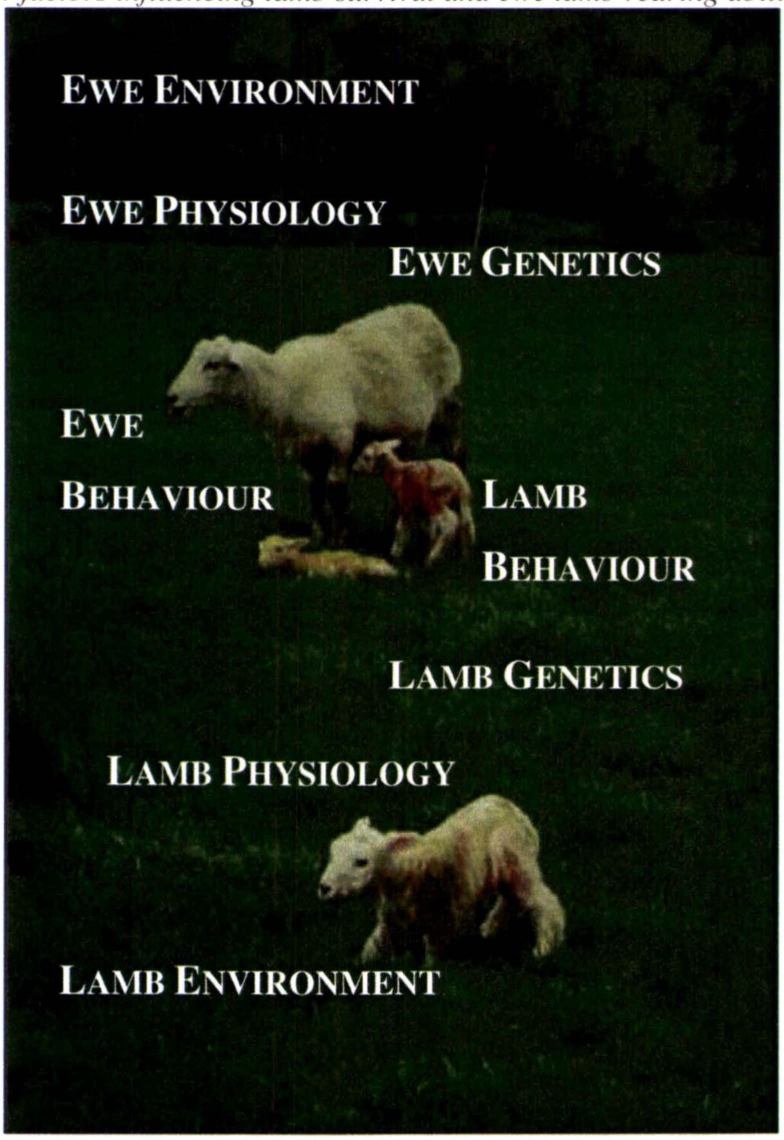
- *Can we identify the lamb and ewe behaviours that encourage ewe- lamb attachment in highly prolific flocks?*
- *Can we identify the management practices on farm that enhance ewe-lamb attachment?*
- *Can we select for improved mothering ability and lamb survival under these conditions?*

The research areas investigated to answer these questions are presented in Figure 1. The format of the thesis follows:

- The first stage of the research required knowledge of current lamb rearing performance on high performing sheep farms in New Zealand. Chapter 2 explores current reproductive rates, lamb losses and management practices through a survey of sheep farmers with high producing flocks.
- Genetic parameters for ewe maternal behaviour score, litter survival and lamb survival are estimated in Chapter 3. The magnitude of environmental and management effects on these ewe and lamb traits has been estimated.
- Environmental effects are investigated further in Chapter 4 and Chapter 9. Chapter 4 investigates the effect of ewe physiology in late pregnancy on maternal behaviour and lamb rearing performance. Maternal nutrition is explored further in Chapter 9 and investigates the effect of pasture allowance in late pregnancy on ewe-lamb attachment behaviours and subsequent lamb rearing performance.

- Breed and line differences in some traits are often regarded as indicative of genetic variation. The objective of Chapters 5 through to 7 is to investigate Finns and Texels which have been previously recognised by New Zealand farmers to have markedly different behaviour. These recently introduced breeds were used to explore the relationship between ewe and lamb behaviours and lamb rearing performance. Chapter 8 investigates the behaviour of a Romney flock divergently selected for maternal IGF-1. A relationship was sought with lamb rearing performance.
- Arena tests were used in Chapter 8 and 9 to determine if maternal behaviour and lamb rearing performance can be predicted before parturition.

*Figure 1 Some factors influencing lamb survival and ewe lamb rearing ability.*




*Photograph taken by Julie Everett-Hincks*

CHAPTER 1

# Literature Review

*Photograph taken by Julie Everett-Hincks*

## 1.1 Introduction

The ability of the ewe to rear her litter to weaning is determined by the successful execution of a number of processes. These are driven by genetics, behaviour and the environment (summarised in Figure 1). A better understanding of perinatal ewe and lamb behaviour will benefit animal production and welfare (Chenoweth and Landaeta-Hernandez, 1998).

The literature review concentrates on the study of ewes and lambs managed outdoors. It reviews studies on ewe and lamb behaviour, genetics and farm management as they relate to lamb survival and lamb rearing performance to weaning.

## 1.2 Background

The evolutionary success of sheep has been due largely to its behaviour. The highly developed flocking instinct and docility of sheep have facilitated their domestication and enabled more effective coexistence with man (Ryder, 1983; Zohary *et al.*, 1998).

Domestication is the process by which wild animals adapt to man and a captive environment. It can be viewed as both an evolutionary process and a developmental phenomenon (Price, 1998). According to Price (1998) artificial selection is the only genetic mechanism unique to domestication and may be applied intentionally (consciously) or inadvertently (unconsciously). Zohary *et al.* (1998) proposed that many of the morphological, physiological and behavioural traits that characterise domestic sheep and distinguish them from their wild ancestors were shaped to a large extent by unconscious selection. Grandin and Deesing (1998) suggested that domestication influenced quantitative rather than qualitative behaviour responses, heightening the response threshold above normal levels of stimulation. They too believed that unconscious selection played a major role and is largely due to mans' role as a buffer between the animal and the environment.

During domestication a number of morphological changes including a reduction in sexual dimorphism, a reduction in male horn size, reduced camouflage coloration and shortening of limbs relative to body size occurred in sheep (Zohary *et al*., 1998).

Humans protect domesticated sheep and with a lowered predation pressure comes relaxed selection pressure for behavioural traits that are effective against predators. Thus there is a reduced flight distance and aggression (Zohary *et al*., 1998). Domestication reduced the risks for females carrying twins therefore relaxing selection against twinning and increasing the frequency of twins (Zohary *et al*., 1998).

Human control over feeding and mating have reduced intraspecies competition (Grandin and Deesing, 1998). Zohery *et al*. (1998) proposed that this reduced intra-population competition, arising from a richer anthropogenic environment compared to the animals wild environment, would lead to automatic selection for accelerated sexual maturation, increased twinning and increased fat storage.

As a result of genetic selection, humans have changed the morphology and physiology of sheep and produced many breeds differing in a range of traits. Key and MacIver (1980) questioned the extent that selection for various physical characteristics resulted in genetically correlated changes in behaviour. Dwyer and Lawrence (1998a) suggested that the intensification of sheep farming and the selection of sheep for increased production have led to a decrease in the expression of behaviours associated with survivability under extensive conditions. Therefore feral breeds of sheep were considered to be superior mothers than the more selected breeds (Dwyer *et al*., 1998b).

## 1.3 Behaviour

Behaviour is an adaptive mechanism, which responds to and alters the internal and external environments of an animal. It can be considered a dynamic interface between the internal and external environment (Grandin and Deesing, 1998).

Maternal behaviour includes those behaviours of the dam which occur around the time of birth and which are associated with the delivery and survival of the young to weaning. The behaviours included becoming isolated, seeking shelter, nest building, parturition, cleaning and stimulating the neonate to suckle and establishment of the mother-young bond (Chenoweth and Landaeta-Hernandez, 1998).

The onset of maternal behaviour in sheep is controlled by levels of oestrogen and progesterone in gestation and the release of oxytocin in delivery (Dwyer *et al*., 1999b). Ewes, especially inexperienced ewes, rely primarily on olfactory cues from amniotic fluid on the lambs' coat for the normal development and maintenance of maternal behaviour at parturition (Levy and Poindron, 1987; Alexander *et al*., 1986; Vince *et al*., 1985, Poindron *et al*., 1980b). The post parturient ewe becomes attached to any newly born lamb, which she has licked for 20-30 minutes (Smith *et al*., 1966).

The behaviour of the ewe before, during and after parturition has a major influence on lamb survival (Nowak *et al*., 2000). The first hour post-partum is the most important in the establishment of an exclusive mother-young bond (Alexander *et al*., 1986). The development of a strong maternal bond is an important prerequisite for lamb survival and it is influenced strongly by continuous association between the ewe and her lamb in the time after birth (Murphy *et al*., 1994a). The formation of the bond is the result of a rapid learning process influenced by both ewe and lamb behaviour (Shillito-Walser, 1978). Shilito-Walser *et al*. (1983) observed that as lambs got older ewes moved away more quickly when disturbed. Lindsay *et al*. (1990) observed that increased vocal behaviour of lambs was strongly associated with their earlier recognition of their mother and better bonding. Nowak (1996) suggested that vocal communication between the ewe and the lamb is central to adequate bond formation and has demonstrated that lamb bleating behaviour is involved in the attachment process. Pollard's New Zealand study showed that when lambs were between 6 and 12 hours old, ewes rearing triplets bleated more when their litters were intact and less when one of their lambs was removed compared with ewes with a single lamb (Pollard, 1992). Pollard (1992) found that a 6-12 hour old lamb, which was separated from its dam, was more likely to approach a ewe that was bleating than a silent ewe and concluded that ewe bleats help in long distance recognition of the dam. Lamb vocalisations are modified by their rearing experience and appear to represent a signal of need (Dwyer *et al*., 1998b).

Ewe-lamb bonding and lamb survival are maximised by management practices that increase the time spent at the birth site by the dam after parturition (Nowak, 1996). Ewes that remain longer on their birth site tend to have higher lamb survival rates (Cloete *et al.*, 1998b). Bonding and consequently survival of twins can be considerably improved if dams remain on the birth site for a minimum of 6 hours (Alexander *et al.*, 1986; Nowak, 1996).

Separation and desertion are likely when the ewe is disturbed (Smith, 1965) and may result from the conflict between the flocking behaviour of sheep and the isolation associated with maternal behaviour (Kilgour and Szantar-Coddington, 1995). Alexander *et al.* (1986) showed that the incidence of separation from twins by inexperienced ewes was high with animals that moved from their birth site soon after giving birth and suggested that intensive management by shepherds could aggravate the loss of lambs. However, Murphy *et al.* (1994a) suggested that it is not so much that the dam is on the birth site for 6 hours after parturition that improves lamb survival but simply the fact that the dam is together with all of her lambs.

The frequency of rejection behaviours declined with maternal experience (Dwyer and Lawrence, 2000) and more frequent abnormal post lambing behaviour occur among 2-year-old primiparous ewes than older ewes (Sharafeldin and Kandeel, 1971). Poor maternal behaviour in primiparous ewes is often considered a cause of lamb death (Arnold and Morgan, 1975) and Dwyer and Lawrence (2000) suggest that the behaviour of a primiparous ewe is reasonably predictive of her behaviour in subsequent pregnancies as individual ewes were consistent in their expression of maternal care across parities. Lindsay *et al.* (1990) suggested training primiparous ewes to the presence of man to reduce emotivity and subsequently improve mothering ability.

Under extensive pastoral conditions Merinos are slow to recognise the size of their litters and inherently poor at maintaining contact with more than one lamb in the neonatal period (Alexander *et al.*, 1983b; Stevens *et al.*, 1982). In one Australian study 46% of twin bearing Merinos became permanently separated from one lamb, mostly on the day after giving birth and in at least 54% of the cases there was no obvious precipitating factor and 34% of twin bearing ewes were separated temporarily from at least one lamb (Alexander *et al*., 1983b). In Merinos the proportion of separations decreased as the time ewes remained near the birth site increased.

Ewe-lamb separation causes emotional stress which influences the behaviour and cortisol response of young animals more markedly than older animals (Napolitano *et al*., 1995). These authors found that the average daily weight gain was lower in lambs that had been separated earlier from the ewe and suggest that the lowered performance is the consequence of a reduced ability of young animals to cope with emotional and nutritional stresses (Napolitano *et al*., 1995).

Thus the temporary separation of a lamb from its dam and its littermates is detrimental to its survival (Nowak and Lindsay, 1992; Alexander *et al*., 1983b; Stevens *et al*., 1982) and later performance (Napolitano *et al*., 1995). Orgeur *et al*. (1998) reported that when ewes and lambs temporarily separated from each other they express their distress by an increase in bleating and locomotor activity. High-pitched bleating is affected by ewe breed and may reflect the likelihood of separation of the ewe from the lamb (Dwyer *et al*., 1998b) but Lindsay *et al*. (1990) suggested that the best mothers were those that were less active in stressful situations and those that bleated more often.

Animals that are used to humans are more easily managed and less timid than those that were not (Markowitz *et al*., 1998). Lambs that have 40 minutes of positive human contact at 1-3 days of age are less afraid of people (Markowitz *et al*., 1998). Murphy *et al*. (1994a) reported that animals of quiet temperament grow faster than animals that are restless, nervous or aggressive animals.

Attempts have been made to find associations with 'emotivity' and reaction of animals to an external stimulus (Alexander *et al*., 1984) and indications are that lamb survival is lower in ewes that are more emotive (Putu *et al*., 1988a). The Arena Behaviour Test has been used in Australia to predict the lamb-rearing ability of Merino ewes (Kilgour, 1998). Kilgour (1998) showed that arena behaviours were useful predictors of lamb survival. Kilgour and Szantar-Coddington (1995, 1997) and Kilgour (1998) reported differences in the total distance travelled and the number of bleats in ewes selected for greater fertility when compared to a random control flock in the arena behaviour test. Murphy *et al*. (1994a) showed that results from their modified arena test were highly repeatable when assessed at weaning, hogget age and 2.5 years. Shillito-Walser *et al.* (1983) tested three breeds of sheep in a T maze to observe the behaviour of ewes when given a choice between going near to their own lambs or going to a group of ewes and lambs from their flock. Maternal behaviour was strongest in Dalesbred, selected for hill farming, with young lambs and the flock tendency strongest in Soays, least domesticated sheep, with older lambs (Shillito-Walser *et al.*, 1983).

The quantification for maternal behaviour is difficult and presents logistical problems especially as the expression of this trait may be influenced by: parity, number of lambs, experience, nutrition and the weather (Poindron and Le Neindre, 1980a).

O'Connor *et al.* (1985) quantified the potential influence of maternal behaviour on lamb survival and growth across a number of traditional and highly fecund ewe breeds and across ewe ages. They established a positive relationship between a Maternal Behaviour Score (MBS) and lamb survival and growth when corrected for litter size, ewe breed and age (O'Connor *et al.*, 1985). The MBS was recorded on a 5-point scale on the response of the ewe to a shepherd handling and tagging her lambs within 24 hours from birth. Lamb survival to weaning increased 10% with an increase in MBS from 2 to 5 and there was an increase in weight weaned per ewe mated with increasing MBS (O'Connor, 1990). MBS is a good indicator not only for lamb growth but also for the strength of the pre-weaning ewe-lamb relationship (O'Connor, 1996). Further studies on MBS by Parker and Nicol (1993) showed that lambs of MBS 4 and 5 ewes located their dam's udder in 30% less time than lambs of MBS 3 ewes. Rapid location of the udder increased immunoglobulin concentration in lamb plasma 24 hours after birth and may contribute to the improved lamb survival and subsequent ewe productivity associated with high MBS ewes (Parker and Nicol, 1992).

Pollard (1989) highlighted the importance of neonatal lamb behaviour in ewe-lamb attachment, especially as litter size increases. Arnold and Morgan (1975) reported that poor maternal behaviour was the direct cause of 16% of lamb deaths, however failure of the lamb to drink after standing caused 23% of lamb deaths. Poindron *et al.* (1980b) emphasised the importance of lamb behaviour and reported that the behaviour of the neonatal lamb influences the maternal responsiveness of the ewe. However many believe that maternal behaviours influence lamb behaviour providing evidence that maternal behaviour at parturition is critical to lamb survival (O'Connor *et al.*, 1992b; Astroshi and Osterberg, 1979, Dwyer and Lawrence, 1999a). Shillito-Walser (1978) also appreciated the importance of effective lamb behaviour concluding that the formation of the maternal-offspring bond in sheep is the result of a rapid learning process influenced by the behaviour of both the ewe and the lamb.

According to Alexander (1988), mother-young acceptance is more likely if the newborn lamb stands soon after birth, sucks soon after standing, follows the mother closely and moves to the mother if separated. A New Zealand study at Ruakura on mixed age Romney ewes concluded that the time taken by a lamb to stand up after birth was the best available indication of vigour (Wallace, 1949). Wallace (1949) observed little or no relationship between vigour and sex, type of birth, age of ewe, birth weight, type of presentation, or time between onset of labour and birth. However, Astroshi and Osterberg (1979) observed that an increase in birth weight shortened the time from birth to standing. Dwyer *et al.* (1999b) showed that the greatest variation in lamb activity was related to maternal progesterone. It is believed that in prolific sheep, birth weight influences behaviour traits, but litter size does not, except indirectly through its effect on birth weight, so the smaller the lamb the less active it is (Atroshi and Osterberg 1979).

Many studies have demonstrated breed differences in perinatal ewe behaviour (Dwyer *et al.*, 1998b, 1999b; Dwyer and Lawrence, 1999a; Fahmy *et al.*, 1996; Shillito-Walser *et al.*, 1983; Key and MacIver, 1980; Lindsay *et al.*, 1990; Cloete *et al.*, 2002) and have attempted to define what particular characteristics make a good mother. O'Connor *et al.* (1985, 1992b) have increased our understanding of maternal behaviour in traditional and highly fecund sheep, however little is known of the effect of lamb behaviour in large litters on formation of the ewe-lamb bond and little is known of their behaviour under extensive New Zealand farming conditions. Research on farm under commercial pastoral conditions is limited with the majority of outdoor studies performed on Merinos, which are not naturally fecund (Alexander *et al.*, 1979; Putu *et al.*, 1988b).

## 1.4 Selection

The variation of mothering ability within and between breeds shows promise for genetic improvement of this important characteristic (Manktelow, 1996). However improvement in mothering ability is dependent upon our success in effectively integrating evolutionary behaviours with modern production systems and then selecting those behaviours that are advantageous for production (Chenoweth and Landaeta-Hernandez, 1998). This statement assumes that we can adequately identify evolutionary behaviours and apply selection pressure to them, without compromising other valuable traits. Therefore a better understanding of the relationship between lamb survival and ewe behaviour are critical for the development of sustainable breeding programmes (Simm *et al.*, 1996).

Breed and line differences in some traits are often regarded as indicative of genetic variation (Hinch, 1997). Breed differences were reported for early neonatal progress in lambs (Slee and Springbett, 1986; Alexander *et al.*, 1990a,b; Cloete *et al.*, 1998b; Cloete *et al.*, 2002), supporting the contention that it is partially under genetic control. Fahmy *et al.* (1996) reported no breed difference in perinatal behaviour in Finn and Cambridge ewes (20% Finn), but Holmes (1976) found poorer maternal ability in Finn ewes compared to Forest Clun ewes and suggested that the poorer maternal ability could have arisen through lack of selection pressure associated with selection for prolificacy from intensive husbandry, as Finn sheep in Europe are predominantly lambed indoors. Whately *et al.* (1974) observed that Merinos and Romneys in New Zealand exhibited poorer mothering ability than the Perendale, Cheviot and Border Leicester Romney cross sheep, crossbred sheep were best. Merino dams were most likely to abandon lambs and Romneys had the poorest ability to seek shelter when lambing in poor weather. Alexander *et al.* (1983a) reported poor maternal behaviour in twin-bearing Merino, Dorset Horn and Border Leicester ewes in Australia.

Dalton *et al.* (1980) found large differences between breeds in lamb survival under New Zealand conditions. Studies of lamb survival in prolific breeds have shown that lamb losses during the first few days after birth constitute between 50 and 75% of all lamb losses (Petersson and Danell, 1985; Dalton *et al.*, 1980; Hinch *et al.*, 1986; Maund *et al.*, 1980). These studies showed a positive relationship between birth weight and lamb survival as litter size increased and identified that dams older than 3 years were more likely to support the survival of large litters. Dawson and Carson (2002) reported similar lamb mortality rates across a range of ewe genotypes however weaned lamb output was greatest for the Bluefaced Leicester x Blackface ewe genotype. Wiener *et al*. (1983) showed that crossbred lambs had better survival rates than purebreds but this advantage was only evident between 3 days and 6 weeks of age.

Selective breeding has been advocated as a means of improving ewe lamb rearing ability and lamb survival under pastoral conditions (Haughey, 1993). However recent estimates of the genetic components of lamb survival indicate limited genetic variation (Petersson and Danell, 1985; Hall *et al*., 1995; Lopez-Villalobos and Garrick, 1999; Morris *et al*., 2000; Fadilli and Leroy, 2001; Cloete *et al*., 2002) and that lamb survival is controlled mainly by non-genetic factors. However, Petersson and Danell (1985) suggest that the maternal genetic influence of lamb survival, that is the dam's provision of an environment in which the offspring performs, is more important than the directly transmitted genetic component of the offspring.

Selective breeding for ewe lamb rearing ability, defined as the ratio of lambs weaned to lambs born, has resulted in a reduction in lamb mortality (Haughey, 1983; Cloete and Scholtz, 1998a) and a reduction in the interval from standing to suckling (Cloete and Scholtz, 1998a). The inference that rearing ability is heritable has been confirmed in few studies with Merinos (Haughey, 1984; Haughey *et al*., 1985) and has been reviewed by Piper *et al*. (1982). The repeatability of rearing performance has also been estimated at 10% by Haughey (1984). Purser and Young (1983) reported that lamb rearing ability was a repeatable trait and that the more lambs reared the better the subsequent performance appeared to be. If the lamb was not reared from the ewe's first parity lamb mortality at age three and parity two was 26.8% but if the previous lamb was reared the mortality was only 13.5% (Purser and Young, 1983). Dalton *et al*. (1980) suggested culling 2 year old ewes that were not pregnant would have a greater effect on improving flock lamb survival than culling ewes that had lost a lamb. Morris *et al*. (2000) found that environmental variances due to permanent maternal effects (for example uterine capacity, pelvic width, milking and maternal ability) were found to contribute mostly to the repeatability of ewe rearing performance providing evidence that improved lamb survival has to be seen mainly as a successful partnership between mother and offspring throughout pregnancy, parturition and lactation.

There has been selection for behaviour traits thought to improve lamb survival, however these studies are scarce (Lambe *et al.*, 2001; Cloete *et al.*, 2002). Lambe's team reported a heritability of 0.13 and a repeatability of 0.32 (Lambe *et al.*, 2001). Cloete *et al.*, (2002) showed that the time to stand from birth and time to suck from standing have a genetic component and that it differs between breeds. In the study of Owens and Armstrong (1985) an increase in lamb birth weight was associated with neonatal lamb vigour in Booroola lambs, although only regression coefficients were reported.

New Zealand sheep farmers have a range of options to influence the genetic capability of their flock. New sheep breeds and the genes they can contribute to the national sheep flock can provide an opportunity to improve lamb-rearing ability. However published estimates of genetic parameters for lamb rearing ability are limited, particularly in highly fecund sheep and selection is limited as lamb rearing ability is a sex-limited trait. Further research is needed to determine the heritability of lamb and ewe behaviours that relate to lamb survival and lamb rearing ability.

## 1.5 Environment and Management

Beilharz and Luxford (1984) discussed the limiting effect of the environment on reproductive progress and accepted that extreme variants like Booroola genes and the application of fertility treatments like Fecundin used for increasing litter size, can only be utilised successfully if the environment is improved. They maintain that even relatively small increases in litter size will need improvements in the environment if they are not to have deleterious side effects (Beilharz and Luxford, 1984). Amer *et al.* (1999) reported that above a litter size of 2.3 lambs born per ewe lambing, farmers can expect a reduction in farm profitability. Triplets replace singles as litter size increases above 1.7 lambs per ewe and lamb mortality is assumed to be highest in triplets before 24 hours post-partum and differs with type of environment and farm (Amer *et al.*, 1999).

Ewes must utilise reserves to support the growth of multiple lambs in utero (Jelbart and Dawe, 1984). The energy cost during pregnancy in the ewe is largely met by increased feed intake, except in very late pregnancy when intake may decline. The ewe may respond to increased nutrient demand in late pregnancy and lactation by eating more, by mobilising maternal tissues, by improving the overall effectiveness of digestion or by increasing the efficiency of utilisation of nutrients by tissues (Jelbart and Dawe, 1984). Mellor (1983) recognises that foetal growth rate is determined by maternal nutrition and placental growth. Placental development is especially important in ewes lambing 150% or more to ensure lambs are sufficiently heavy at birth and to give them the best chance of survival (Mellor, 1983; Bell, 1984).

In late pregnancy and early lactation the nutritional requirements of ewes are very high, particularly for ewes with twins (Holmes, 1975). The last 4-6 weeks before lambing are critical (Scales *et al.*, 1986). When multiple bearing ewes were offered additional feed in late pregnancy to increase liveweight, lamb mortality was reduced, suggesting merit in improved pre-lamb feeding for ewes carrying more than one lamb (Scales *et al.*, 1986). Scales and co-workers reported that a 10kg increase in ewe liveweight during the last 6 weeks of pregnancy resulted in an increase of 0.46kg in singles and 0.52kg in twins at birth (Scales *et al.*, 1986). Ideally ewes with multiples should be identified as early as possible, separated and preferentially fed (Geenty, 1997).

Hight and Jury (1970) reported that lambs born to ewes fed well in late pregnancy are better equipped to survive conditions predisposing to exposure and starvation as they have more energy stored as brown fat reserves and maintain their suckling drive for longer than lambs born to poorly fed ewes. Moore *et al.* (1986) reported that lambs born from ewes fed higher pasture allowances had higher rectal temperatures at birth than those born from low allowance ewes indicating the lambs poorly fed in utero tend to achieve high metabolic rates more slowly than those which receive a good nutrient supply (McCutcheon *et al.*, 1981). Moore and co-workers (1996) also observed that increased lamb vigour was associated with increasing birth weight for all lambs, but increasing rectal temperature was associated with increasing birth weight only for male lambs. However, Robinson *et al.* (1977) reported that the level of feeding in late pregnancy did not affect foetal weight in highly fecund Finn crosses.

Inadequate feeding of ewes can result in poor maternal behaviour and poor ewe behaviour is an important cause of lamb death (Nowak, 1996). Dwyer *et al.* (2003) demonstrated that a moderate reduction in maternal nutrition in late pregnancy resulted in a quantitative reduction in the expression of maternal behaviours, in particular MBS, at parturition under intensive conditions indoors. The same authors did not observe a change in neonatal lamb behaviour from the effect of maternal under nutrition and concluded that neonatal progress was affected by birth weight (Dwyer *et al.*, 2003).

Nowak (1996) observed a considerable improvement in twin lamb bonding with their dam and twin lamb survival when the mother remained on the birth site for a minimum of 6 hours. Lindsay *et al.* (1990) observed that the time spent on the birth site increased when ewes with twins were on a higher plane of nutrition 6 weeks before lambing. Putu *et al.* (1988a) observed that pasture conditions during late pregnancy had no effect on time spent by the ewes on the birth site. However twin-bearing ewes remained on the birth site for significantly longer than ewes with a single lamb. In twin bearing ewes low level of nutrition resulted in a higher proportion of permanent desertions of at least one of their twin lambs (19.2%) compared with ewes on a high level of nutrition (4.3%) (Putu *et al.*, 1988a). If paddock pasture quality and feeding levels are good and the paddock has adequate shelter then the ewe will stay at the birth site with her lambs for a longer period (Pollard and Littlejohn, 1999; Putu *et al.*, 1988b).

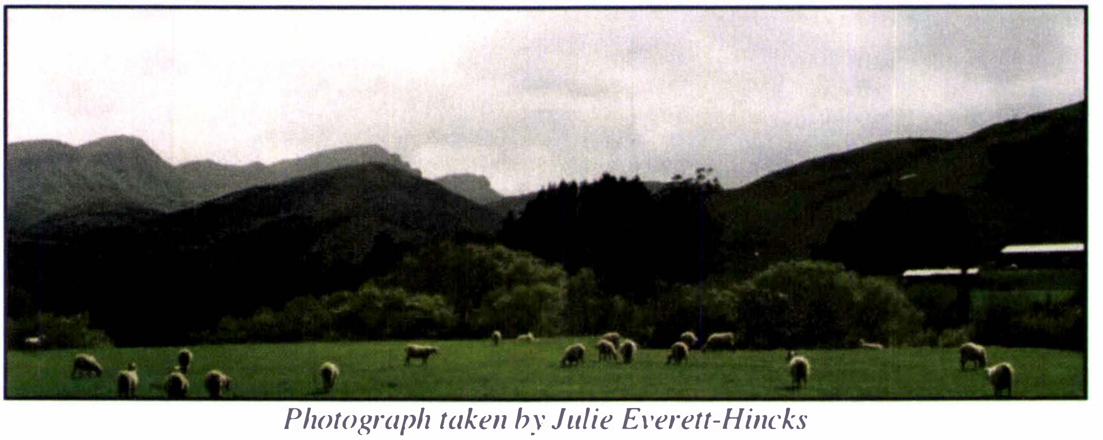
Studies have attempted to define suitable husbandry practices for the increased lambing rate and to encourage ewe-lamb attachment and subsequently survival immediately after birth. In a national survey of farmer practices at lambing, Aspin (1997) identified that when selecting paddocks for lambing priority considerations were: pasture cover, shelter, stocking rate and topography. However these factors were not defined. Pollard and Littlejohn (1999) investigated sheltering behaviour of lambing sheep under extensive conditions and types of shelter did not affect lamb productivity in the one-year of study, where weather was moderate. They did however observe that least used artificial shelters were near roadways and human activity reinforcing the ewe's need to seek isolation. Ducker and Fraser (1973) investigated husbandry practices indoor and also compared indoor with outdoor practices at lambing. They concluded from their indoor trials that poorer husbandry resulted in increased lamb mortality, particularly amongst twin lambs. The ewe-lamb relationship benefits from the absence of interference from flock mates with lambs ingesting more colostrum with outdoor lambing (Ducker and Fraser, 1973). However for New Zealand conditions, the effect of season and weather on survival is the most important source of variability (Johnson *et al.*, 1982; Pollard and Littlejohn, 1999; McCutcheon *et al.*, 1981).

Studies investigating the effect of nutrition on the behaviour of the ewe and lamb are scarce and have predominantly been performed on Merinos, which are not naturally fecund (Putu *et al.*, 1988a), under artificial conditions (Dwyer *et al.*, 2003), or have not adequately defined the behaviours that are affected (Moore *et al.*, 1986).

Many studies have investigated ewe and lamb behaviour and Pollard (1989) and O'Connor *et al.* (1985) have made a significant contribution investigating ewe and lamb behaviour in litter sizes larger than two under extensive New Zealand conditions. However, this literature review highlights the research deficits that exist and therefore this thesis attempts to add to the current literature by investigating the management and genetic factors which affect maternal and neonatal lamb attachment behaviours for larger litters under pastoral grazing conditions and explores their relationship with lamb survival to weaning.

# CHAPTER 2

# Lamb rearing success on high performing sheep farms



*Photograph taken by Julie Everett-Hincks*

Related publications:

Everett-Hincks *et al.* (2001). Survey of high performing sheep farmers: lamb rearing experience. *The 6th Congress for the Association of Advanced Animal Breeding and Genetics.*

## 2.1 Summary

Data collected from 181 New Zealand sheep farmers were segregated into two groups; a high farm group with at least 150% lambs weaned and a low farm group with less than 150% at weaning.

The percentage lamb losses per ewe were similar between groups, therefore by maintaining losses similar to the Low group, the High group had greater lamb production to weaning. High lamb rearing success to weaning was observed in both groups (163%, 134%) compared to the national average of 115% to tailing for the 1999/2000 season (Anon, 2002), which was not surprising as high performing sheep farmers were surveyed. Both groups identified mothering ability as the most important factor affecting lamb survival.

Management practices were investigated to explain how the High farm had greater lamb production to weaning. Ewe feeding levels prior to lambing were similar for the two groups, however shepherding frequency was significantly higher in the High farm group compared with the Low farm group and higher compared to shepherding frequencies reported in earlier studies (Aspin, 1997). Increased shepherding frequency has probably led to greater lamb production by maintaining low lamb losses in the High farm group.

## 2.2 Introduction

A report by McKinnsey and Company recommended that farmers should target an on-farm productivity increase of 5% per annum to offset a long-term decrease in farm product prices (Anon, 2000). This increase will depend on the adoption of technologies and farm management disciplines used by leading farmers.

The lamb meat market remains strong and has increased from an average 1999 season lamb price of $40.30 to $71.25 for the 2001 season (Anon, 2002). Improved lambing percentage is the most important factor used to generate higher profits on sheep farms (Geenty, 1997). Farmers wanting to produce more lambs per ewe mated are using highly fecund breeds such as the Finnish Landrace and East Friesian, hogget mating or increasing ewe ovulation rate through the use of fertility treatments. However, an increase in the number of lambs born per ewe is only valuable if lambs survive and comes at a cost if pregnancy and lambing are not managed appropriately.

In 1981 Rohloff and co-workers surveyed 180 Otago and Southland high performance flocks (Rohloff *et al*., 1982). The aim of that survey was to assess what management changes had accompanied the rise in lambing percentage. Feed supply during lambing and early lactation and lamb mortality were the main concerns of farmers with flocks exceeding 150% lambing. Lamb mortality ranged from 9.4% for lower lambing percentage flocks (130-149%) to 13.8% for the highest performing flocks (+170 %).

This paper explores current reproductive rates, lamb losses and management practices through a survey of sheep farmers with high producing flocks.

## 2.3 Materials and Methods

One hundred and eighty one sheep farmers identified by farm consultants and breed groups took part in a survey. The farmers were achieving a high lambing percentage for their farming conditions.

The questionnaire was designed and compiled by Julie Everett-Hincks, Kevin Stafford and Hugh Blair from Massey University. The survey form contained twenty four questions and requested that answers be based on 1999 production figures. Information was requested on farm description, sheep selection and culling policies, size and age structure of the flock and management policy. Lamb production records were requested with particular emphasis on percentage lamb losses, lamb rearing performance and cause of ewe and lamb deaths.

To objectively separate the respondents into two groups a cut-off lambing percentage of 150% was used. Data were segregated based on the Monitor Farm mean for the 1999 season plus two standard deviations (i.e. 125% + (2 x 13%)), which was 150% (Anon, 1999). 69% of the respondents had greater than 150% lambs weaned per ewe mated, whereas 31% had less than 150% at weaning. The groups will be referred to as High and Low farm groups for the purposes of this chapter. The High and Low farm groups were established to determine if the High farm group and Low farm group had different management practices to keep lamb mortality low. The term lambing percentage used in the survey and in this chapter is taken as lambs weaned per 100 ewes mated.

Farmers were asked to report the percentage of lamb deaths from lambing to 2 days of age (stage 1) and from day 2 to weaning (stage 2) for ewes carrying singles, twins and triplets. They were also asked to estimate the level of importance of listed factors that affect lamb survival. If they believed the trait was not important they scored it 1, slightly important 2, important 3, very important 4 and extremely important 5.

Farmers were asked to describe their sheep management system and name their 'major' and 'second' sheep breeds. Farm management practices were reported and the proportion of farms actively partaking in specified management practices (e.g. shepherding) were recorded. Frequency of shepherding at lambing was also requested.

The sheep breeds, feed management and trait importance levels were analysed using chi-squared procedures by Excel (Microsoft Office). Differences between High and Low farms for post parturient lamb losses at different stages were tested by analysis of variance using General Linear Model procedures (PROC GLM) (SAS, 2000). Shepherding frequency at lambing was analysed using the Student t-test. Outlying values were identified and removed using plot procedure methods (PROC UNIVARIATE PLOT) (SAS, 2000).

## 2.4 Results

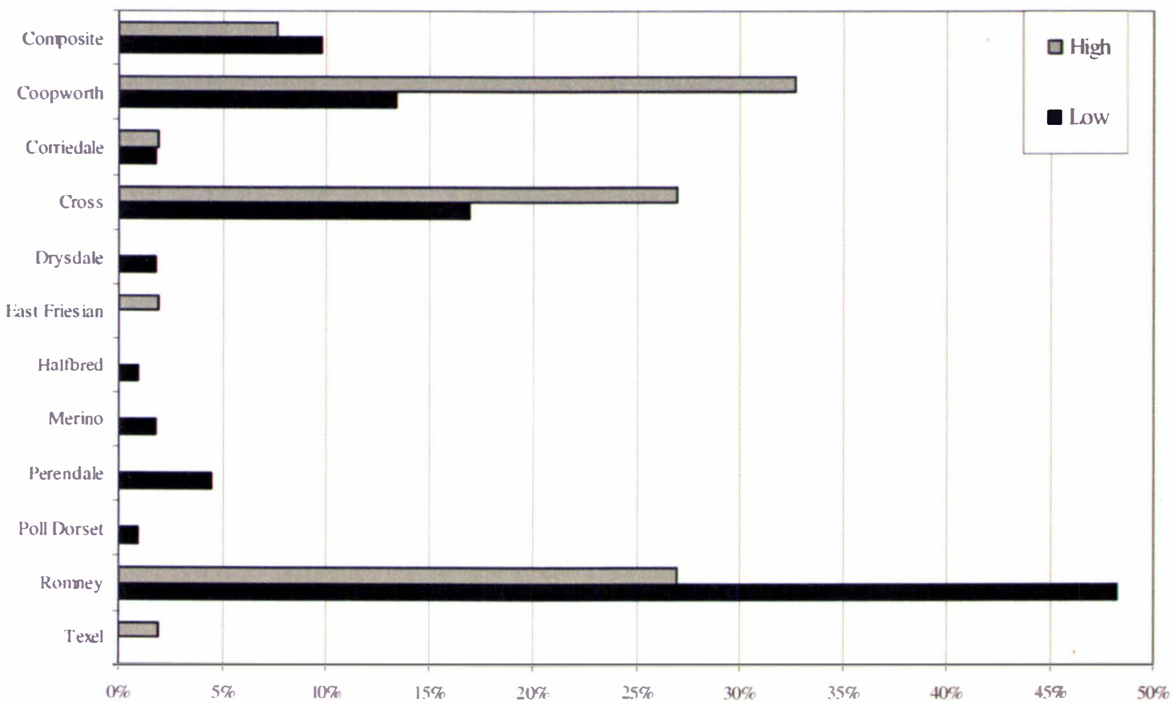
From 450 farmers, 181 (40%) returned the questionnaire and details of these are shown in Table 2.1. The mean lambing percentage at weaning for all respondents was 143%.

*Table 2.1 Summary description of farms surveyed.*

| | High Farms | | Low Farms | |
|---|---|---|---|---|
| Parameter | Average | Range | Average | Range |
| Farm size (Hectares) | 365 | 33 - 1675 | 711 | 92 - 25000 |
| Sheep stock units per farm | 3863 | 556 – 18700 | 4223 | 407 - 22000 |
| Lambing % at weaning | 163% | 150% - 200% | 134% | 78% - 149% |
| Cattle stock units per farm | 387 | 0 – 4300 | 445 | 0 – 4800 |
| Deer stock units per farm | 69 | 0 – 700 | 75 | 0 – 2200 |
| Sheep percentage of total stock units | 75% | 21% - 100% | 69% | 9% - 100% |
| Stocking rate over winter (SU/Ha) | 16.9 | 6 - 35 | 16.5 | 1 - 55 |

A greater proportion of High farms practice hogget mating (60 ± 7%) than Low farms (45 ± 5%) ($P<0.10$). The proportion of farms scanning ewes during pregnancy was similar between High (69 ± 6%) and Low (77 ± 2%) farms ($P>0.05$).

*Figure 2.1 Major sheep breeds on respondents farms.*

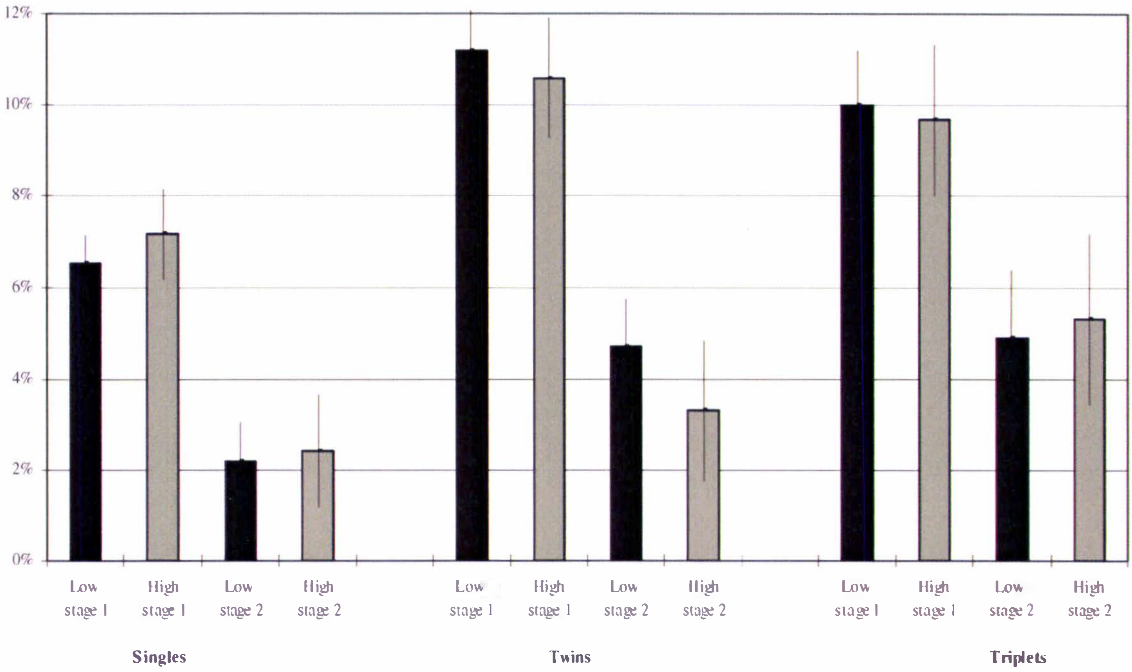



The major sheep breeds farmed differed significantly between High and Low farms when analysed according to farm (Figure 2.1) and sheep number ($P<0.05$). The majority of High farms had Coopworth sheep, while Low farms had Romneys. Crosses (defined as a two breed combination) were the second major sheep type farmed, followed by Composites which were defined as a three or more breed combination (Figure 2.1).

There were no significant differences in post-parturient lamb losses, in either stage 1 or stage 2, between the High and Low farms ($P>0.05$) (Figure 2.2).

Respondents from both High and Low farms considered lamb survival to be the most important trait affecting farm profit. Both groups of respondents agreed that mothering ability was the most important factor affecting lamb survival (Table 2.2). Respondents in the High farm group believed breed of lamb to be of least importance while those in the Low group believed ram breed to be of least importance (Table 2.2). The order of factors differed between the two groups.

*Figure 2.2 Percentage of post parturient lamb losses by litter size and High, Low farm (standard error included).*




*Stage 1 = lamb losses from birth to 2 days of age.*
*Stage 2 = lamb losses from 2 days of age to weaning.*

*Table 2.2 The importance of factors affecting lamb survival according to respondents from High and Low farm groups.*

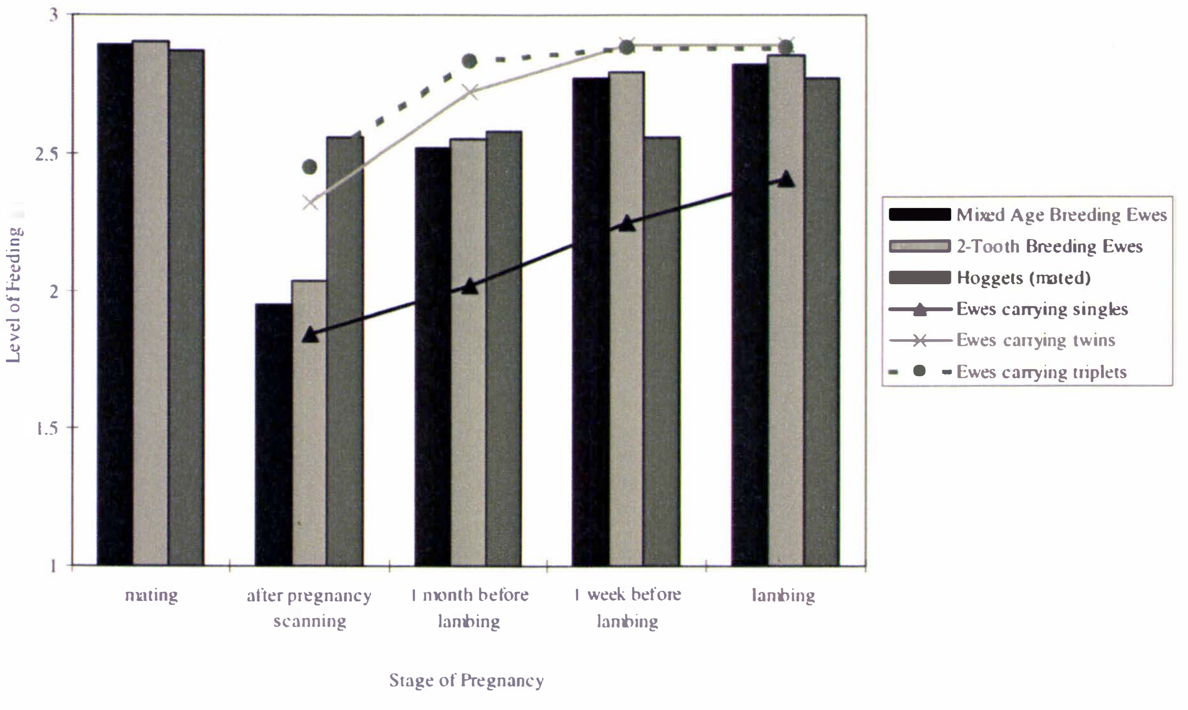
| | High Mean | Low Mean | P |
|---|---|---|---|
| Mothering ability | 4.5 | 4.4 | ns |
| Feed management at lambing time | 4.3 | 4.4 | ns |
| Feed management throughout pregnancy | 4.3 | 4.1 | ns |
| Farm management | 4.2 | 4.2 | ns |
| Ewe health | 4.1 | 4.3 | ns |
| Shelter | 4 | 4.1 | ns |
| Ewe breed | 3.9 | 3.6 | ns |
| Ram breed | 3.7 | 3.4 | * |
| Breed of lamb | 3.6 | 3.6 | ns |

ns = not significant; *P<0.05.

Farmers in the Low farm group reported lamb losses of 7% as a direct result of 'poor mothering ability' up to 2 days of age, compared with 6% reported by the High farm group. High and Low farm groups estimated that 84% and 81% respectively of breeding ewes raised all of their lambs every year. These differences were not statistically significant (P>0.05).

There was no significant difference between the High and Low farms in the level of feeding from mating through to lambing (P>0.05).

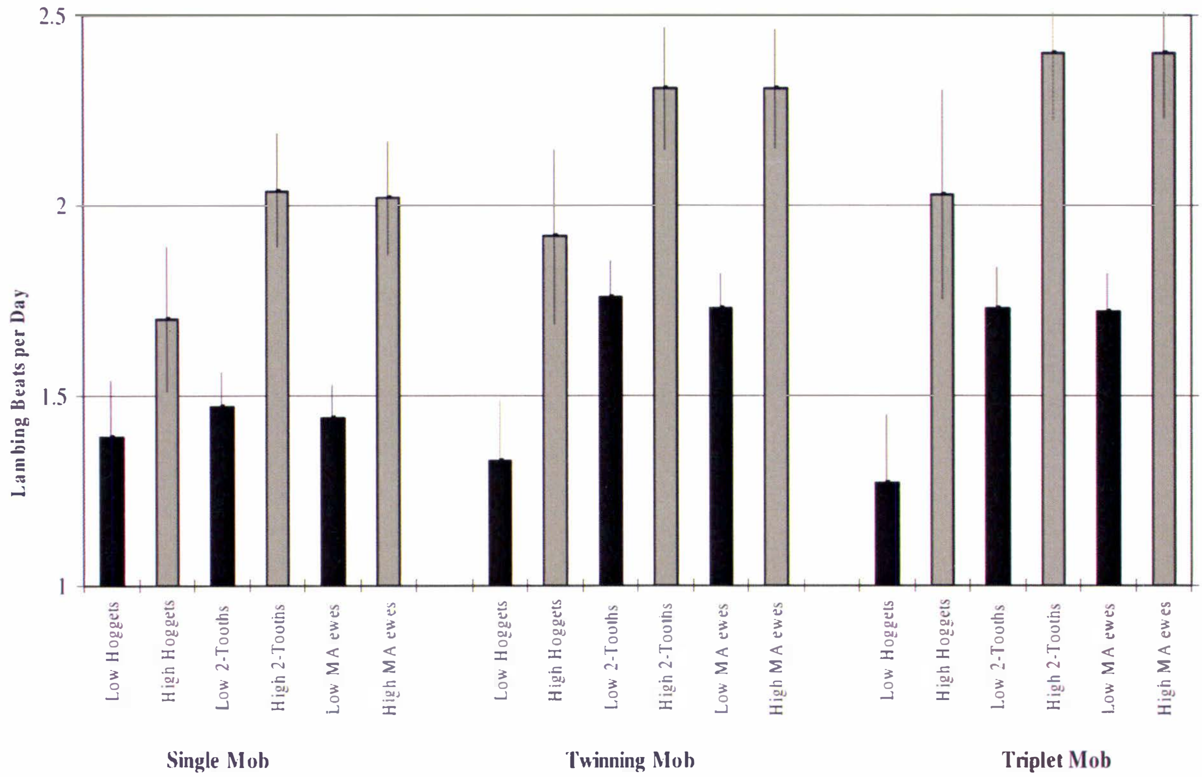
*Figure 2.3 Mean feeding levels for different ewe groups at different stages of pregnancy for all the farms surveyed (Feeding level: 1=below maintenance; 2=maintenance and 3=above maintenance).*




Ewes were allowed higher pasture levels at mating time than throughout pregnancy (Figure 2.3). Two-tooth and mixed age breeding ewes were on a rising plane of nutrition between pregnancy scanning and lambing. Mated hoggets were fed the same level from pregnancy scanning through to one week prior to lambing and their feed allowance was increased at lambing. Ewes carrying twins or triplets were fed on a similar rising plane of nutrition over pregnancy. Ewes carrying a single lamb were offered a rising plane of nutrition over pregnancy but were fed lower levels than ewes with twins or triplets.

The majority of farmers (80%) shepherded their ewes at least once a day during lambing. On High farms there was more shepherding at lambing than on Low farms with all ewe classes (Figure 2.4). High farms shepherded hoggets with single lambs fewer times than other groups of ewes (Figure 2.4).

*Figure 2.4 Mean shepherding frequency for sheep raising singles, twins and triplets on High and Low farms (standard error included).*




The difference in shepherding frequency between High and Low farms was significant for mixed age ewes ($P<0.001$), 2-tooth ewes ($P<0.001$), hogget twinning ($P<0.05$) and all tripleting ($P<0.05$) mobs.

## 2.5 Discussion

As lambing percentages increase, the proportion of ewes having singles, twins and triplets alters. Triplets become more prevalent as prolificacy increases from 1.7 lambs born per ewe (Amer *et al*., 1999). As a general rule, greater lamb losses are expected with triplets than twins or singles (Johnson *et al*., 1982; Hinch *et al*., 1983; Scales *et al*., 1986). Lamb losses from both farm groups reported here were low compared to results reported by Aspin (1997) and Geenty (1997) and similar to Rohloff *et al*. (1982). Rohloff *et al*. (1982) also reported that lamb mortality increased as lambing percentage increased. The lack of significant differences in lamb losses between the High and Low farms in this study suggests that lamb-rearing ability to weaning was superior on the High farms. Increased shepherding at lambing by the High farmers may have reduced lamb mortality and increased the number of lambs weaned so that mortality rates were comparable with Low farms.

Farmers surveyed by Rohloff and co-workers twenty years ago, attributed the increase in lambing performance to the Coopworth breed (Rohloff *et al*., 1982) and Coopworths were the predominant ewe breed on High farms in this study. Chapter 3 further investigates lamb rearing performance and mothering ability in the Coopworth breed. Genetic parameters for maternal behaviour score, litter and lamb survival were estimated in Carthews Coopworth flock where there has been selection for improved mothering ability and lamb survival for nearly three decades (Chapter 3).

Aspin (1997) reported that 12% of farmers in the MRDC survey mated hoggets and 54% had used pregnancy scanning. In our study a larger proportion of High farms mated hoggets (High: 60%; Low 45%) and approximately 70% of all farmers pregnancy scanned their breeding ewes.

Farmers in the High farm group reported lower lamb losses as a result of poor mothering ability than farmers in the Low farm group, but this difference was not statistically significant. O'Connor *et al*. (1985) reported an increase in maternal behaviour score with an increase in litter size. Maternal behaviour score (MBS) is an indicator of mothering ability and measures the ewe's response to the shepherd when her lambs are caught for tagging. The non-significant trend in improved mothering ability in the High farm group, might be partly explained by an increased litter size and a greater acceptance of the shepherd, from increased shepherding exposure, leading to lower lamb losses. Chapter 3 investigates the effect of maternal behaviour score on lamb and litter survival and investigates factors that influence maternal behaviour score such as litter size and dam age.

Increased shepherding intensity at lambing improves rearing success and as a consequence is encouraged by animal welfare groups (Geenty, 1997). The High group farmers shepherded more than Low group farmers. Aspin (1997) reported that 62% of respondents surveyed in 1995 shepherded their ewes during lambing and this had increased to 80% in this study. Increased shepherding may be associated with increased lamb prices. This survey targeted high performing sheep farms and if they can be considered a representation of the sheep farmer population, the results presented here translate to a 12% increase in shepherding at lambing in four years.

Increased shepherding at lambing may need to be reviewed when farming more emotive and/or different sheep breeds and when feeding levels are low at lambing, as lamb desertion may be more prevalent under these conditions leading to higher lamb losses. The effect of feeding levels before and at lambing on mothering ability and lamb rearing performance were investigated in Chapter 9.

## 2.6 Conclusions

An improvement in lamb survival is possible for the national flock if genetics for lamb rearing ability and management practices are recruited from high performing sheep farms. In particular, shepherding frequency at lambing may be the primary management reason why significantly more lambs were weaned per 100 ewes mated in the High farm group.

This survey presents a snapshot of industry practices and the information gathered must be interpreted with caution.

# CHAPTER 3

# The effect of ewe maternal behaviour score on lamb and litter survival

*Photograph taken by Julie Everett-Hincks*

Related publications:

Everett-Hincks *et al*. (2004). Effect of ewe maternal behaviour score on lamb survival and litter survival. *Submitted to the Journal of Agricultural Science, Cambridge.*

Everett-Hincks *et al*. (2002). Genetic variation in maternal behaviour score and lamb survival. *The 7$^{th}$ World Congress on Genetics Applied to Livestock Production, Montpellier France, 19-23 August, 2002. 14.*

## 3.1 Summary

The study was carried out on a commercial New Zealand sheep farm with high ewe reproductive rates and lamb survival produced through intensive selection in its Coopworth flock for maternal ability.

Heritability and repeatability estimates were derived for ewe maternal behaviour score (MBS) and litter survival (LIS). Heritability estimates were derived for lamb survival as a trait of the lamb (LAS) over all lambs, for twin (LAS2) and for triplet (LAS3) lambs.

MBS and LIS were measured on 1954 dams, for a maximum of four parities: 1997, 1998, 1999 and 2000. MBS was measured at tagging on a 5-point scale (1=poor, 5=excellent), when the dam's lambs were between 12 and 36 hours old. The mean MBS in this study was 3.3 and increased with litter size. LIS was measured from birth to weaning. Mean litter survival was 83%. LIS increased significantly as MBS increased ($P<0.01$). LIS decreased as the size of the litter increased ($P<0.01$). Age of dam was a non-significant effect on LIS ($P>0.05$).

LAS was measured from birth to weaning on 4171 Coopworth lambs. Mean LAS was higher for lambs born as twins compared to lambs born as singles and lowest for lambs born as triplets ($P<0.01$). LAS was lower for lambs born to dams aged 2 years. This effect was significant for all lambs, regardless of litter size at birth and for the triplet lamb dataset ($P<0.01$). The effects of age of dam and sex of lamb on twin lamb survival were not significant ($P>0.05$). Ewe lamb survival rate was higher when compared to ram lambs in the full dataset, however the relationship was reversed for the triplet lamb dataset where ram lamb survival was greatest ($P<0.01$). LAS decreased as the MBS of its dam increased ($P<0.01$). The relationship was significant for lambs in the full dataset and twin dataset ($P<0.05$).

MBS and LIS were under minimal genetic control. The heritability and repeatability for MBS were 0.05 and 0.07 respectively. The heritability and repeatability for dam LIS were 0.0 and 0.11. Heritability for LAS over all lambs attributed to direct effects was 0.14 while the heritability attributed to maternal effects was 0.11. The heritability for twin (LAS2) and triplet (LAS3) lamb survival differed. Heritability attributed to direct

and maternal effects were 0.0 and 0.21 respectively for twin lambs and 0.08 and 0.16 respectively for triplets.

The genetic correlation between maternal and direct effect for LAS was –0.74. It is possible that the genes that regulate physiological and biochemical processes for survival are incompatible with the genes that enhance ewe-lamb bonding. For example the genes that regulate the physiological factors to reduce gregariousness at parturition may in fact be the same genes that encourage isolation in the neonate from its littermates and dam.

There is minimal genetic variation in this flock for lamb survival and maternal traits. Low genetic variation suggests that selection will be ineffective and that farmers must consider environment and management techniques for improving lamb survival.

## 3.2 Introduction

In New Zealand, many sheep breeders have selected and bred ewes for increased fecundity traits over the last two decades. The relationship between lambing rate and lamb survival is poorly understood in highly fecund ewes. Davis *et al.* (1983) reported that the ratio of ewes having singles and twins changed as litter size increased to 1.7 lambs per ewe. Triplets replace singles as litter size increases above 1.7 lambs per ewe. This increase in triplets is of concern to farmers. Twin and triplet born lambs have higher mortality rates than singles (Hall *et al.*, 1988). Lamb survival is a problem with up to 30% of lambs dying between pregnancy scanning and tailing (Aspin, 1997). This level of lamb mortality is not acceptable from a production and animal welfare perspective.

There has been some selection for traits thought to improve lamb survival, such as the maternal behaviour score (MBS), described by O'Connor *et al.* (1985). A better understanding of the relationship between lamb survival and maternal behaviour is critical for the development of sustainable breeding programmes (Simm *et al.*, 1996). However, few farms in New Zealand have incorporated MBS into their ewe selection and culling programmes.

The objectives of this study were to investigate the effect of maternal behaviour score (MBS) on litter (LIS) and lamb survival (LAS) for Coopworth ewes and to estimate the heritability and repeatability for MBS, LIS and LAS. The genetic correlation between maternal and direct effects for lamb survival was also estimated.

# 3.3 Materials and Methods

## 3.3.1 Background

The Carthew family run a stud and commercial sheep operation in the Wairarapa region of New Zealand. Their predominant objective is to improve the maternal ability of their ewes. They have been selecting Coopworth ewes for mothering ability since 1974 when they recognised the need for good mothering ability to ensure lamb survival in their high performing sheep management system.

## 3.3.2 Animals and Measurements

A Maternal Behaviour Score (MBS) similar to that described by O'Connor *et al.* (1985) was recorded on Coopworth dams. The MBS was scored on a 5-point scale based on the distance a ewe retreats from her lambs when the shepherd is tagging them (Table 3.1). This scoring system has been used on this flock for over 25 years and ewes with an MBS of 1 have been culled annually. Due to low subclass numbers MBS were grouped into three categories; scores 1 and 2 were grouped, MBS 3 stayed as it was and scores 4 and 5 were grouped.

*Table 3.1 The maternal behaviour scores at tagging and the number of animals used in this study.*

| Description of Maternal Behaviour Score (MBS)[1] | Original MBS[1] | Combined MBS | Total number of dams in this study |
|---|---|---|---|
| Ewe flees at the approach of the shepherd, shows no interest in the lambs and does not return | 1 | 2 | 13 |
| Ewe retreats further than 10 metres but comes back to her lambs as the shepherd leaves them | 2 | 2 | 27 |
| Ewe retreats to such a distance that tag identification is difficult (5-10 metres) | 3 | 3 | 1796 |
| Ewe retreats but stays within 5 metres | 4 | 4 | 107 |
| Ewe stays close to the shepherd during handling of her lambs | 5 | 4 | 11 |

[1] as described by O'Connor *et al.* (1985).

Litter survival (LIS) was measured from birth to weaning in Coopworth dams (n=1954). LIS was calculated by dividing litter size at weaning by litter size at birth and recorded as a percentage.

Lamb survival as a trait of the lamb (LAS) was calculated from birth to weaning. Lambs were tagged between 12 and 36 hours after birth. Lambs that survived to weaning were given a score of '1' while those that did not were given a score of '0'. LAS was recorded for Coopworth lambs (n=4171).

### 3.3.3 Statistical Analyses

Animal performance records from the Sheep Improvement Limited (SIL) national sheep recording database and lambing books from the Carthew's were used to generate data sets with which to calculate genetic parameters for MBS, LIS and LAS. SIL is a joint venture Meat and Wool Board company which combines the three previous New Zealand recording schemes Studfax, Animalplan and FlockLinc (MacGillivray, 2000).

Data were edited to remove missing records and recording errors. The final dataset consisted of 1954 dams with MBS and LIS values and 4171 lambs with LAS records. Four years of lambing data, from 1997-2000, were included in the analyses. A pedigree file containing the sire, dam, and paternal and maternal grandparents of each animal was used to form a relationship matrix. Variance and covariance components were estimated using ASREML (Gilmour *et al*., 1998).

The model for MBS included the fixed effects of parturition group, age of dam at parturition and litter size at birth. The model also included animal and permanent environmental random effects. Parturition group was derived by grouping the lamb birth dates into 4 to 6 ten-day periods depending on the lambing spread in each year. Due to low subclass numbers, animals 6 years of age and older were grouped into age group 6.

The model for LIS included the fixed effects of parturition group, age of dam, litter size at birth, MBS and animal and permanent environmental random effects.

Separate analyses were performed for lamb survival from birth to weaning as follows:

1. Lamb survival records for single, twin and triplet lambs (n=4171) were analysed together to provide genetic parameter estimates over all lambs born (LAS).
2. Lamb survival records for twin lambs (n=2658) were analysed separately to provide genetic parameter estimates (LAS2).
3. Lamb survival records for triplet lambs (n=1209) were analysed separately to provide genetic parameter estimates (LAS3).

The model for LAS included the fixed effects of litter size at birth, birth year of lamb, sex of lamb, age of dam and MBS. Litter size at birth includes litters of singles, twins and triplets. All dams older than 2 years of age were grouped into age group 3. Random effects included a direct additive genetic effect and a maternal genetic effect. Estimates of (co)variance components were obtained after logit transformation. Logit transformation was necessary as LAS is a binary trait, lambs that do not survive to weaning are recorded as '0' whereas lambs that survive are recorded as '1'. The models for LAS2 and LAS3 differed from that of LAS in that they did not include the fixed effect of litter size at birth.

Heritabilities, repeatabilities and genetic correlations were calculated from the variance components produced by ASREML (Gilmour *et al*., 1998). The total heritability was obtained by summing the genetic variances attributed to direct and maternal effects and the direct-maternal covariance. The total heritability reflects the resemblance between parents and offspring after allowing for the covariance between direct and maternal effects. Failure to account for the negative covariance between direct and maternal effects for lamb survival would have resulted in inflated heritability estimates.

# 3.4 Results

## 3.4.1 Environmental Effects on MBS and LIS

The mean MBS in this study was 3.3 (± 0.036). MBS was relatively consistent for ewe age groups 1 to 5 years (Table 3.2). MBS increased with increasing litter size ($P<0.05$) (Table 3.3). Mean MBS did not change throughout lambing in 1997, 1998, 1999 and

2000 (MBS 3.2 to 3.3), however in 2000 MBS tended to increase from late September (MBS 3.6 ± 0.05) through to the end of lambing (MBS 3.8 ± 0.07). This coincided with an increase in shepherding intensity, which was not a factor of previous years analysed in this study.

Mean LIS over all dams was 82.7% (± 1.5). Litter survival tended to increase from age 2 to 4 years and then decrease (Table 3.2) (P>0.05). LIS decreased as litter size increased (P<0.01) (Table 3.3). LIS was lowest for the first half of the 2000 lambing season (70% ± 0.20) (P<0.01). This coincided with stormy weather, which was not a factor of the previous lambing years analysed in this study.

*Table 3.2 The effect of age of dam on maternal behaviour score and litter survival (least squares mean ± standard error).*

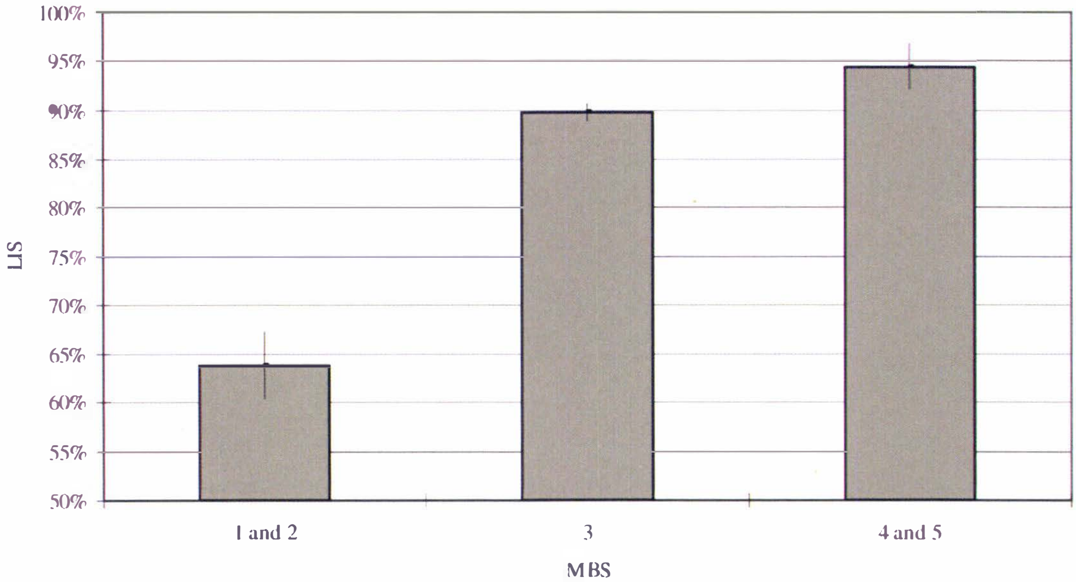
| Dam Age (Years) | Number of dams | LIS | MBS |
|---|---|---|---|
| 1 | 72 | 82.5% ± 3.1 | 3.18 ± 0.052 |
| 2 | 684 | 80.1% ± 1.6 | 3.16 ± 0.033 |
| 3 | 440 | 82.6% ± 1.7 | 3.19 ± 0.034 |
| 4 | 379 | 85.3% ± 1.8 | 3.21 ± 0.035 |
| 5 | 233 | 84.2% ± 1.9 | 3.19 ± 0.037 |
| 6 + | 146 | 81.3% ± 2.3 | 3.32 ± 0.043 |

*Table 3.3 The effect of litter size at birth on maternal behaviour score and litter survival (least squares mean ± standard error).*

| Litter size at birth | Number of dams | LIS | MBS |
|---|---|---|---|
| 1 | 260 | 89% ± 1.9 | 3.13 ± 0.029 |
| 2 | 1239 | 85% ± 1.6 | 3.11 ± 0.023 |
| 3 | 455 | 75% ± 1.6 | 3.21 ± 0.025 |

LIS increased with increasing MBS (P<0.01) (Figure 3.1). A substantial improvement in LIS was observed in dams with an MBS of 3 compared to dams with an MBS of 1 and 2. An increase in MBS above 3 has a minimal effect on litter survival.

*Figure 3.1 The effect of maternal behaviour score (MBS) on litter survival (LIS) (least square means and standard errors).*




## 3.4.2 Environmental Effects on Lamb Survival

Litter size at birth, age of dam, sex of lamb, birth year of lamb and MBS had a significant effect on LAS over all lambs (P<0.01). LAS was highest for twin lambs and lowest for triplets (Table 3.4). LAS was 86% for lambs born to ewes 2 years of age and younger and 91% for lambs born to ewes older than 2 years. This trend was observed in dams with triplets but not for dams with twins (Table 3.4). LAS to weaning was 89% for ewe lambs and 88% for ram lambs (P<0.01). Ewe lamb survival was higher than ram lamb survival for all lambs, however the relationship was reversed for triplets (P<0.01). The birth year of lamb had a significant effect on LAS, LAS2 and LAS3 (Table 3.4). Lamb survival was lowest in the 2000 lambing year, which coincided with prevalent stormy weather that was not a factor of previous years in this study.

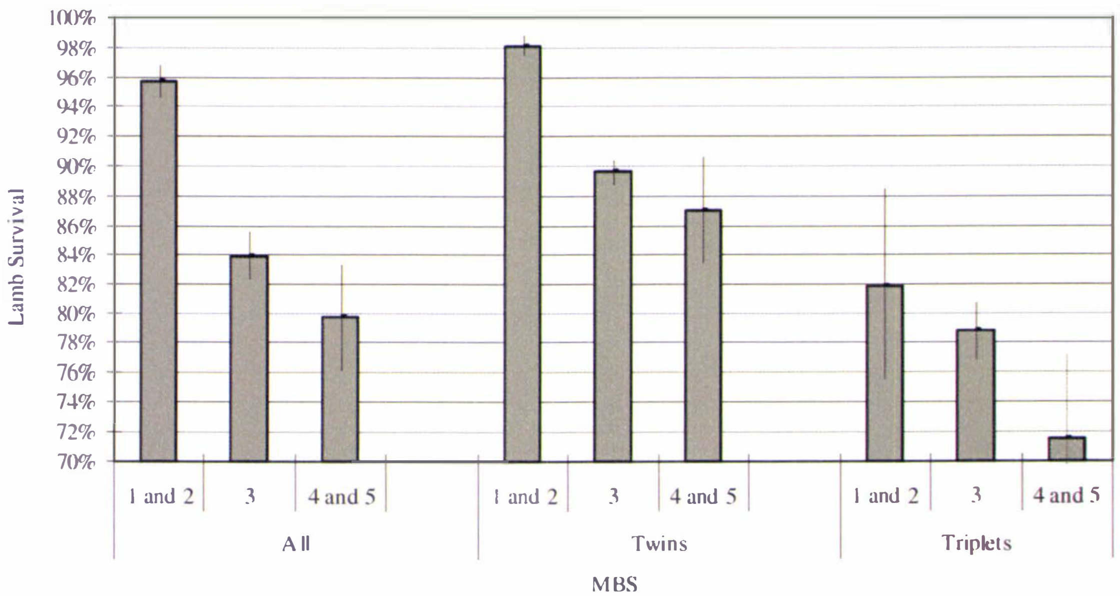
*Table 3.4 The effect of age of dam, sex of lamb and birth year of lamb on lamb survival from birth to weaning (least squares mean ± standard error).*

| | LAS (all) | LAS2 (twin) | LAS3 (triplet) |
|---|---|---|---|
| Number of records | 4171 | 2658 | 1209 |
| Overall LAS mean | 89% ± 1.5 | 94% ± 0.9 | 78% ± 3.1 |
| | | | |
| Dam age 2 years and younger | 86% ± 1.9 | 93% ± 1.3 | 73% ± 4.3 |
| Dam age 3 years and older | 91% ± 1.3 | 94% ± 0.9 | 82% ± 2.9 |
| P (dam age) | ** | ns | ** |
| | | | |
| Ram lambs | 88% ± 1.7 | 93% ± 1.2 | 79% ± 3.4 |
| Ewe lambs | 89% ± 1.5 | 94% ± 1.0 | 76% ± 3.6 |
| P (lamb sex) | ** | ns | ** |
| | | | |
| 1997 | 92% ± 1.8 | 96% ± 1.0 | 79% ± 4.9 |
| 1998 | 89% ± 1.9 | 94% ± 1.3 | 77% ± 5.2 |
| 1999 | 92% ± 1.6 | 95% ± 1.2 | 84% ± 3.6 |
| 2000 | 78% ± 2.9 | 86% ± 1.7 | 68% ± 4.2 |
| P (birth year) | ** | ** | ** |

ns = not significant at P=0.05, * P<0.05, ** P<0.01.

LAS decreased as the MBS of the lamb's dam increased (Figure 3.2). This relationship was significant for all flock lambs and for twins. A major decrease in lamb survival was observed in lambs whose dam had an MBS of 3 compared to those with an MBS of 1 or 2. Standard errors were large for MBS relating to triplet lamb survival.

*Figure 3.2 The effect of maternal behaviour score (MBS) on lamb survival from birth to weaning (least squares mean ± standard error).*



### 3.4.3 Genetic Parameters for MBS and LIS

Genetic parameters for MBS and LIS are shown in Table 3.5. Both heritability and repeatability for MBS and LIS were low. The low repeatabilities indicating that a dam with a high MBS or LIS in one lambing year is unlikely to have the same MBS or LIS in subsequent lambing years. MBS exhibits low genetic variation (Table 3.5), with temporary environmental effects accounting for 93% of the total variation. The major source of variation in LIS also appears to be due to temporary environmental effects, which accounted for 89% of the total variation.

*Table 3.5 Estimated variance components for maternal behaviour score (MBS) and litter survival (LIS) (standard error included).*

| Dam Traits: | MBS | LIS |
|---|---|---|
| Number of records | 1954 | 1954 |
| Number of sires used | 55 | 55 |
| Trait mean | 3.31 ± 0.036 | 82.7% ± 1.5 |
| $\sigma^2$ permanent environment | 0.0015 ± 0.004 | 0.005 ± 0.002 |
| $\sigma^2$ genetic | 0.005 ± 0.003 | 0.000 ± 0.000 |
| $\sigma^2$ total animal | 0.007 ± 0.003 | 0.005 ± 0.002 |
| $\sigma^2$ temporary environment | 0.088 ± 0.004 | 0.039 ± 0.002 |
| $\sigma^2$ total phenotypic | 0.095 ± 0.003 | 0.044 ± 0.001 |
| $h^2$ direct | 0.05 ± 0.034 | 0.00 ± 0.00 |
| Repeatability | 0.07 ± 0.036 | 0.11 ± 0.038 |

### 3.4.4 Genetic Parameters for Lamb Survival

Variance and covariance component estimates for LAS, LAS2 and LAS3 are presented in Table 3.6. For LAS the heritability attributed to direct effects was 0.14 while the heritability attributed to maternal effects (expressed when the ewe lamb produces progeny of her own) was 0.11. The genetic correlation between maternal and direct effects for LAS was –0.74.

The heritability for LAS2 differed from LAS3 (Table 3.6). The heritability attributed to direct effects was 0.0 for LAS2 and 0.08 for LAS3. The heritability attributed to maternal effects for LAS2 was 0.21, higher than that found for LAS3 (0.16).

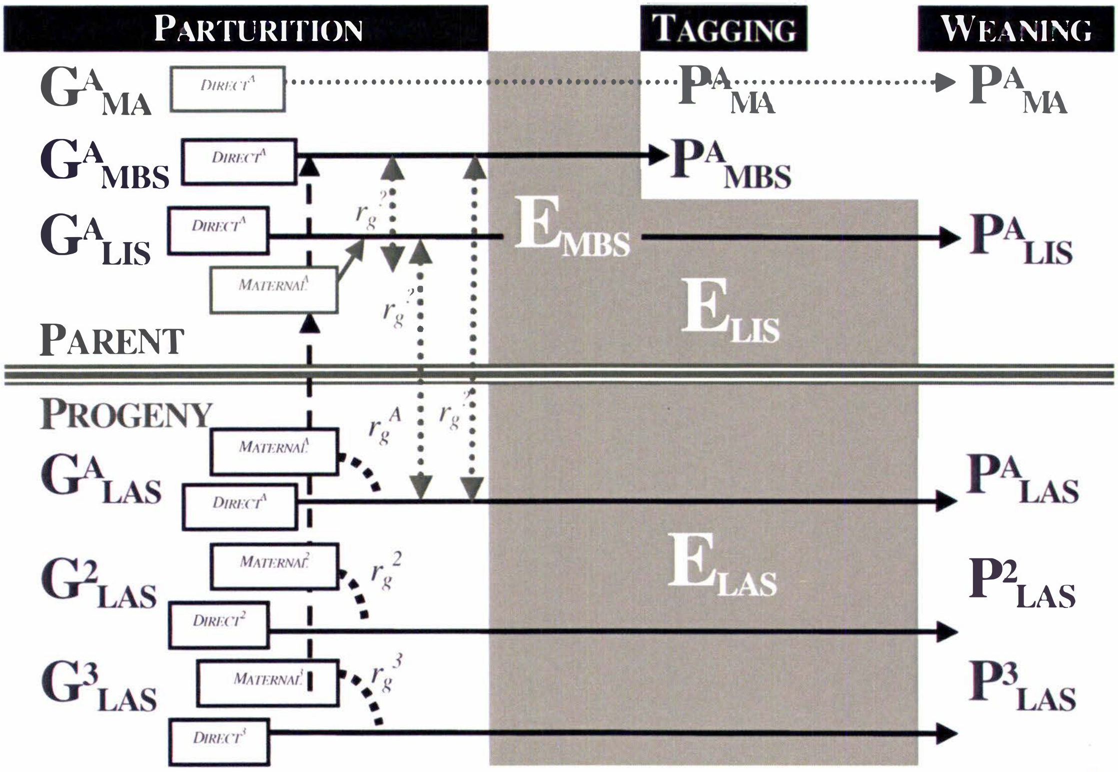
*Table 3.6 Estimated variance components for lamb survival from birth to weaning (standard error included).*

| Lamb Traits: | LAS (all) | LAS2 (twin) | LAS3 (triplet) |
|---|---|---|---|
| Number of records | 4171 | 2658 | 1209 |
| Number of sires used | 55 | 54 | 46 |
| $\sigma^2$ direct animal | 0.55 ± 0.188 | 0 ± 0 | 0.28 ± 0.258 |
| $\sigma^2$ genetic maternal | 0.43 ± 0.232 | 0.79 ± 0.371 | 0.59 ± 0.408 |
| $\sigma$ direct maternal covariance | -0.36 ± 0.223 | -0.22 ± 0.293 | -0.49 ± 0.401 |
| $\sigma^2$ total genetic | 0.62 ± 0.158 | 0.58 ± 0.198 | 0.10 ± 0.052 |
| $\sigma^2$ total phenotypic | 3.91 ± 0.158 | 3.87 ± 0.198 | 3.67 ± 0.212 |
| $h^2$ direct | 0.14 ± 0.044 | 0 ± 0 | 0.08 ± 0.067 |
| $h^2$ maternal | 0.11 ± 0.057 | 0.21 ± 0.09 | 0.16 ± 0.107 |
| $h^2$ total | 0.16 ± 0.034 | 0.15 ± 0.044 | 0.10 ± 0.052 |
| Correlation direct and maternal | -0.74 ± 0.26 | not estimable | -1.20 ± 0.495 |

## 3.5 Discussion

In this study a ewe's mothering ability was assessed when she was given a maternal behaviour score (MBS) at tagging time. This is represented as $P_{MBS}$ in Figure 3.3. Figure 3.3 provides a summary of the genetic pathways for MBS, LIS and LAS. Other indicators for maternal ability, measured at tagging and at weaning are represented by $P_{MA}$, these behavioural and physiological factors require further work to determine if they have a genetic component ($G_{MA}$). The phenotypes for LIS as a parent and LAS for the progeny are illustrated in Figure 3.3 as $P_{LIS}$ and $P_{LAS}$ respectively. Figure 3.3 demonstrates that some of the same temporary environmental factors ($E_{MBS}$) that influence $P_{MBS}$ also contribute to $P_{LIS}$ generating the positive relationship seen between $P_{MBS}$ and $P_{LIS}$ in Figure 3.1. Maternal genetic variation for lamb survival is expressed a generation later in the ewe's MBS phenotype ($P_{MBS}$) and fully expressed in the ewe's LIS phenotype ($P_{LIS}$). The negative covariance in direct and maternal effects partly explains the phenotypic relationship seen in Figure 3.2. LAS ($P_{LAS}$) tended to decrease as MBS ($P_{MBS}$) of the lamb's dam increased. However standard errors associated with LAS3 means were large due to low numbers of triplet lambs born to dams with high and low maternal behaviour scores. However, this trend should not be overlooked, as the MBS could be an indirect indicator for lamb lethargy as observed in triplets whose development has been restricted by the maternal environment. It may be that lambs born with higher levels of vitality form stronger dam-lamb bonds in a shorter time and therefore have moved off the birth site sooner. This requires further investigation.

*Figure 3.3 The genetic pathways for maternal behaviour score (MBS), litter survival (LIS) and lamb survival to weaning (LAS).*




*G = Genotype for the trait specified (assuming that ½ genes each are from the sire and the dam), P=Phenotype, E=Environmental effects and rg = genetic correlation between direct and maternal effects. rg? = genetic correlation between parent and progeny traits unknown and requires future investigation. The genotype for maternal ability (MA) is also unknown and also warrants investigation. Symbols with superscript A refer to all lambs (singles, twins and triplets), superscript 2 refer to lambs born as a twin and superscript 3 refers to lambs born as a triplet.*

The farm investigated in this study has been using the MBS as a dam selection criterion for nearly 30 years. Lamb survival rates were high compared to the national average of around 80% (Geenty, 1997; Aspin, 1997). Therefore, prolonged use of the MBS system has most probably led to the high survival rates experienced on this farm, particularly in twin lambs (94%).

The heritability estimate for MBS in this study is less than that reported by Lambe *et al.* (2001) but they investigated the use of the MBS in two flocks previously unselected for the trait. Lambe's team reported larger genetic and permanent environmental variances for MBS, with a heritability of 0.13 and a repeatability of 0.32. In the current study animals with an MBS of 1 were culled from the flock each year, thus censoring the data. In an effort to identify the effect of censoring, the data were modified to include dams, which were culled on MBS, in the following year with their MBS increased to 2. The permanent environmental variance increased from 0.0015 to 0.0095, increasing the repeatability from 0.07 to 0.19. The heritability remained unchanged at 0.05. Therefore the low heritability found in this study does not appear to be the result of censored data. The MBS of Lambe *et al.* (2001) differed from our study in that it was assessed on a 6-point scale with a mean of 4.0 and 4.3 for farm 1 and 2 respectively and maternal grandparents were unknown in their genetic analyses. The level of fecundity and litter survival in the flock analysed by Lambe *et al.* (2001) were different to the flock used in this study. The average litter size for Lambe's flock was 1.34 lambs per dam compared with 1.8 in this study, whilst litter survival to weaning was approximately 80% compared to Carthews flock mean of 83%. The flock investigated in this study had larger litters at weaning compared with Lambe's flock.

Researchers have attempted to predict the heritability and repeatability of rearing ability (Piper *et al.*, 1982; Haughey, 1984), however no estimates have been derived from animal performance records. When Morris *et al.* (1996) treated lamb survival data as a trait of the dam instead of the lamb, they reported the heritability for lamb survival to be very low (0.02). In this study the genetic and permanent environmental variances estimated for MBS and LIS were both small suggesting that the major source of variation in these traits was due to temporary environmental effects. For example, stormy weather was a major factor affecting litter survival in the year 2000. Changes to shepherding intensity can also be considered a temporary environmental effect. MBS increased across the flock as the lambing period progressed and as the ewes became more familiar to human interference through increased shepherding.

Estimates of total heritability (direct + genetic maternal + direct-maternal covariance) for preweaning lamb survival were greater than that reported by Morris *et al.* (2000) (0.029) and Lopez-Villalobos and Garrick (1999) (0.042). Lopez-Villalobos and Garrick (1999) estimated the value for maternal permanent environmental variance to be 0.353 using a logit scale, which accounted for 9% of the total variation. This again suggests that the temporary environmental component of the maternal effect is the main contributor to variation in lamb survival. Assuming the permanent environment accounts for 9% of the total variation in the current study, the temporary environment accounts for around 75% of the total variation in LAS and LAS2. However for LAS3 the temporary environmental component accounts for 88% of the total variation, reaffirming the heightened importance of the environment for triplet lamb survival.

For twin lambs genetic variation attributed to direct effects is zero whilst genetic variation attributed to maternal effects (expressed a generation later) is 0.21 and higher than that for triplets. The reason for the difference in proportions of variation attributed to direct effects and maternal effects in twins and triplets is unclear. However it can be assumed that a significant limiting factor for a twin lamb's prenatal and postnatal growth and survival is its genotype rather than the maternal environment. The ewe has two uterine horns and two teats; therefore the breeding ewe has the physical capability to manage a litter size of two. McDonald *et al.* (1981) reported that triplet and quad foetuses were more variable in weight within litters than were twins. The difference increased with foetal age and was attributed to increased competition between foetuses that were located within the same horn of the uterus. The relatively low variability in weight between twins is most likely because in most twin litters there is only one foetus in each horn of the uterus. In triplet litters one foetus may be alone in a horn with the other two in the other horn. Therefore the maternal environment, from conception through to weaning, is the limiting factor for triplet lamb survival. As energy demands and appetites increase, competition for placental nutrients and mothers milk becomes more acute and triplet lambs draw on their own genetics to survive rather than rely on the maternal genetics of their dam to ensure their survival.

The genetic correlation between direct and maternal genetic effects for LAS in this study (-0.74) was greater than the value (-0.257) reported by Lopez-Villalobos and Garrick (1999). The negative correlation between direct and maternal effects for lamb survival suggests that selection for animals with superior survival to weaning have inferior genes for survival of their own progeny when they become mothers. Within breed opportunities for genetic improvement of lamb survival will be limited by the magnitude of this correlation. Greater genetic improvement might be possible by developing separate selection strategies for two lines or breeds, which could then be crossed for maximum benefit.

The lamb survival trait recorded in its current form requires review. Currently the trait is a binary trait; a lamb is either given a score 0 or 1. Lambs that survive to weaning are given a score of '1' while those that do not are given a '0'. The trait is observed over a 100 day period, from day of birth to weaning, therefore temporary environmental effects make up nearly 90% of the variation in lamb survival and 100% in litter survival. Numerous environmental factors influence lamb and litter survival over this period including weather and stock management practices and explain why previously reported estimates for lamb survival have been low and genetic improvement limited. Animal selection programmes have adjusted lamb survival for litter size, however previously ewe litter size rarely exceeded two lambs whereas over the past two decades selection has been for increasing litter size with litters of two and three lambs now common. This study has shown that genetic and environmental variation differs for lambs born as a twin or triplet and environmental effects play a greater part in triplet lamb survival than twin lamb survival. Therefore greater genetic improvement is possible if genetic parameters for lamb survival are separately estimated for ewes with a single lamb, twins and triplets.

MBS gives an indication of a dam's degree of attachment to her lambs and/or birth site versus her attachment to the flock in the first one to two days following parturition when challenged with human presence. In the wild, females of some ungulate species, which are normally highly gregarious, seek social and spatial isolation prior to parturition. The period of seclusion may last from several hours up to 2 weeks (Langbein *et al.*, 1998). This spatial isolation from the flock may aid the development of the dam-young attachment. It is possible that the genes that regulate physiological and biochemical processes for survival are incompatible with the genes that enhance dam-lamb bonding. For example the genes that regulate the physiological factors to reduce gregariousness may in fact be the same genes that encourage isolation in the neonate from its littermates and dam. Early separation of the lamb from the ewe affects the humoral immune response and later performance of the lamb and is possibly the consequence of a reduced ability of young animals to cope with emotional and nutritional stresses (Napolitano *et al.*, 1995). Emotional stress influences the behaviour of young animals more markedly than older animals. The behaviour of both ewes and lambs need to be considered as it would seem that it is not necessarily 'poor' maternal behaviour but inappropriate lamb behaviour that is a limiting factor in triplet lamb survival (O'Connor and Lawrence, 1992a; Chapter 9).

This study has highlighted the importance of temporary environmental effects on all traits investigated and emphasises the need to identify the management practices around lambing that enhance lamb survival, in particular triplet lamb survival (see Chapter 4 and 9). LIS in this study was measured from birth to weaning and is a true measure of a dam's lamb rearing ability whereas the MBS is only an indicator of lamb rearing ability. LIS did increase with an increase in MBS and Lambe *et al.* (2001) reported significantly more lambs dying before weaning from ewes with a MBS of 1. O'Connor *et al.* (1985) suggested that an MBS increase with litter size may represent a stimulation of maternal behaviour by additional lambs. Hinch (1989) reported that at all ages single lambs were usually further from their dams than were multiples.

Ewe-lamb attachment and lamb survival are maximised by management practices that increase the time spent at the birth site by the dam after parturition and ensure that the appropriate interactions occur between the dam and her lambs on the birth site (Nowak, 1996). Bonding and consequently survival of twins can be considerably improved if dams remain on the birth site for a minimum of 6 hours (Murphy *et al.*, 1994a). If pasture quality and feeding levels are good and the paddock has adequate shelter then the ewe will stay at the birth site with her lambs for a longer period (Pollard and Littlejohn, 1999). Temporary environmental effects, such as paddock design, feeding levels and shelter availability require further investigation to determine their effect on lamb and litter survival. The effect of feeding levels before and at lambing on lamb and litter survival is investigated in Chapter 9.

As suggested by Murphy *et al.* (1994a), it is not so much that the dam is on the birth site for 6 hours after parturition that improves lamb survival but simply the fact that the dam is together with all of her lambs. It is accepted that separation of a lamb from the litter is detrimental to its survival. Nowak and Lindsay (1992) concluded that the ability of twin lambs to discriminate their dams from alien ewes 12 hours after birth is related to survival during the neonatal period. Lamb and maternal behaviour should be investigated conjointly to identify the physiological factors that have the greatest impact on the formation of a successful ewe-lamb bond.

Selection for maternal behaviour at tagging may have led to behavioural adaptations in the flock studied. In this flock, poor mothers, as identified by the MBS system, were culled from the performance-recorded flock. Individuals that are best adapted to their current environment survive and reproduce, passing on the attributes they possess to future generations through their genes and/or their ability to teach their young. The formation of the ewe-lamb bond is the result of a rapid learning process influenced by both the behaviour of the dam and the lamb (Shillito-Walser, 1978). Losers in the struggle to survive die before they have a chance to breed, or they produce few offspring.

## 3.6 Conclusions

In this flock there is little benefit to be gained from including maternal behaviour score and litter survival in the animal selection programme, as this study shows:

- Genetic variation and consequently heritability for MBS and LIS are small.
- Permanent environmental variance for both MBS and LIS are small.
- Repeatabilities for MBS and LIS are low.

Genetic gains in lamb survival to weaning are possible across this flock (LAS) and for twins (LAS2), however the total heritability is still low. Total heritability for triplets is lower than that for twins and highlights the need to manage tripleting ewes with more care. The negative correlation between maternal and direct effects must be incorporated into animal breeding programmes so that lamb survival can be improved. One option is to establish separate selection lines for each trait and then cross these for maximum benefit. The economics of this option require consideration.

The influence of temporary environmental effects on maternal behaviour score, lamb and litter survival highlights the importance and significance of farm and animal management practices in extensive New Zealand farming systems. Farmers considering using fertility treatments, such as the vaccine Androvax™ (used to increase ewe ovulation rate), should anticipate the rising litter size and put a management plan in place to encourage lamb and subsequently litter survival. One option is to avoid administering fertility treatments to young and inexperienced ewes.

It appears that if management practices and environmental conditions are conducive to high levels of litter survival, then the incorporation of the MBS into the animal selection programme is likely to be of little benefit. Arguably, if management practices and environmental conditions have not been integrated in such a way as to enhance litter survival, then the MBS may have a place. However, a new measure of maternal behaviour as it relates to lamb rearing success is needed for flocks with higher litter survival rates if litter survival is to increase further.

Further work is needed to identify the management practices and environmental conditions that have the greatest effect on lamb and litter survival. Once identified, stock managers must then manipulate these management practices with the aim to improve twin and triplet lamb survival.

CHAPTER 4

# The effect of pregnant ewe physiology on maternal behaviour score and lamb production

*Photograph taken by Julie Everett-Hincks*

Related publications:

Everett-Hincks *et al*. (2004). The effect of ewe nutrition on maternal behaviour score and lamb production. *Submitted to the New Zealand Society of Animal Production.*

## 4.1 Summary

Mothering ability was investigated in two breeds of sheep with twin and triplet litters in 2000. The study was carried out on a commercial sheep farm with high reproductive rates gained through intensive selection in its Coopworth flock and the introduction of East Friesian genes by crossbreeding.

East Friesian Coopworth (EFCoop) ewes maintained body condition between pregnancy scanning whereas Coopworth ewes lost body condition. Plasma β-hydroxybutyrate (β-OHB) was significantly higher in Coopworth ewes prior to lambing. Coopworth and EFCoop ewes with triplet litters had elevated levels of plasma β-hydroxybutyrate concentration compared to ewes with twins.

Coopworth ewes had higher triplet litter survival rates to tagging compared with EFCoop ewes. The maternal behaviour score (MBS) of ewes was determined within 24 hours of birth on the basis of their response to the shepherd tagging their lambs on a 5-point scale from 1 (ewe leaves litter and does not return) to 5 (ewe remains within 1m of litter) (O'Connor *et al.*, 1985). The maternal behaviour score (MBS) was higher in Coopworth ewes than the EFCoop ewes and increased with litter size but remained constant for EFCoop ewes regardless of litter size.

Lamb production to weaning was generally similar between breeds. Coopworth ewes with triplet litters and lower MBS at tagging weaned the lowest weight of lamb. However Coopworth dams with a high MBS produced an additional 10kg of lamb to weaning, this being comparable to their EFCoop contemporaries.

The results of this study suggest that ewes that maintain condition in late pregnancy provide a more suitable maternal environment to support and grow their litters. This is increasingly important for triplet litters. This study shows that a ewe that has slightly higher plasma β-hydroxybutyrate levels, is not as receptive to the demands of her litter and is sensitive to human interference as indicated by lower MBS.

## 4.2 Introduction

Lamb survival is very important in highly fecund flocks. Triplets become more common as prolificacy increases above 1.7 lambs born per ewe (Amer *et al.*, 1999) and greater lamb losses are expected with triplets than twins or singles (Johnson *et al.*, 1982; Hinch *et al.*, 1983; Scales *et al.*, 1986). Most losses occur in the first two days after birth, adequate and proper maternal care is required to minimise losses and the detrimental effects of the environmental (Poindron *et al.*, 1984). Increased fecundity has highlighted maternal constraints that were less obvious in flocks with lower fecundity prevalent 10-20 years ago when most studies were undertaken.

Crossbreeding is now widely practiced by sheep farmers and is one of the tools used over the past decade to increase ewe fecundity and lamb survival. However, there is little published information on whether breed substitution or crossbreeding to highly fecund breeds results in improved mothering ability and lamb production in the extensive New Zealand sheep-farming environment. This Chapter focuses on the comparison of straightbred Coopworth and East Friesian Coopworth cross sheep, whereas Chapters 5, 6 and 7 investigate whether either of the recently introduced Finnish Landrace and Texel breeds have particular traits of interest to improve lamb rearing performance in the national sheep flock.

There has been limited study of maternal behaviour in highly fecund sheep in New Zealand and Australia. O'Connor *et al.* (1985) made a valuable contribution investigating the effect of Maternal Behaviour Score (MBS) on lamb survival across a number of breeds including the prolific Booroola and crosses. Ron Kilgour and co-workers made useful observations in the 1960's and 1970's on maternal behaviour, however these studies were with ewes averaging about 100% lambs at docking. Recent Australian studies have also advanced understanding on maternal behaviour but they used either Merino or Merino Border Leicester crosses (Kilgour, 1998). However we now have a better understanding of maternal behaviour score and its affect on lamb and litter survival in Coopworth sheep farmed under commercial New Zealand conditions (Chapter 3). This study showed that a ewe's maternal behaviour and litter survival are under minimal genetic control and the major source of variation in these traits is due to temporary environmental effects (Chapter 3). However we have yet to identify the environmental factors that have the greatest effect on maternal behaviour and subsequently lamb rearing performance in ewes with larger litters.

A better understanding of maternal behaviour and the mechanisms which control it will be helpful when assessing existing problems, such as increased lamb mortality. It is necessary to examine if the mechanisms which control maternal behaviour operate differently over a range of environmental conditions for different breeds and breed combinations. With this information appropriate management techniques can then be identified and appropriate animal breeding programmes formulated to reduce lamb mortality. Chapter 9 investigates the effect of pasture allowance in late pregnancy on maternal behaviour and lamb rearing performance.

In late pregnancy and early lactation the nutritional requirements of ewes are very high. The last 4-6 weeks before lambing are critical (Scales *et al*., 1986). Nutrition during this period of pregnancy determines lamb birth weight and nutritional disorders of the ewe such as pregnancy toxaemia. In ewes, plasma concentrations of β-hydroxybutyrate (β-OHB) reflect the balance between fat mobilisation and the capacity to utilise ketone bodies produced. Fat mobilisation is dependent on the amount of fat stored in the body and on the difference between the intake of and demand for nutrients (Foot *et al*., 1984). Foot and co-workers (1984) suggested plasma concentration of β-OHB be used as an index of the inadequacy of intake of nutrients by ewes to meet their energy requirements during periods of high demand. Russell *et al*. (1967) found that ewes grazing pasture with a plasma β-OHB concentration of 0.71 mmol/*l* were in energy balance. 'Moderate' under nourishment and 'severe' under nourishment gave rise to plasma concentrations of 1.1 and 1.6 mmol/*l* respectively. Plasma β-hydroxybutyrate levels rise as more of the body's energy comes from the metabolism of fats (Guyton, 1991).

Many factors can affect mothering ability and lamb rearing performance. This study investigates ewe body condition and plasma β-OHB concentrations in late pregnancy and how they influence mothering and lamb rearing ability in two highly fecund sheep breeds.

# 4.3 Materials and Methods

## 4.3.1 Background

The Carthew family run a stud and commercial sheep operation in the Wairarapa. Their predominant breeding objective is to improve the maternal ability of ewes. They have been selecting Coopworth ewes for maternal ability since the 1970's to ensure good lamb survival in their sheep management system.

East Friesian genes have recently been introduced into the commercial Coopworth flock. East Friesian crosses have been performance recorded since 1997. Differences in the performance and behaviour of the Coopworth and East Friesian cross ewes and their lambs have been observed. The research focused on the comparison of straightbred Coopworth and East Friesian Coopworth cross (EFCoop) sheep.

## 4.3.2 Animals and Measurements

Mixed age ewes scanned with twins and triplets in the 2000 lambing season were monitored in this study. There were 432 Coopworth ewes (352 ewes with twins and 80 with triplets) and 103 East Friesian Coopworth cross (EFCoop) ewes (75 with twin litters and 28 with triplets).

At pregnancy scanning ewes carrying twin and triplet foetuses were identified by a Real-time Ultrasound Scanner (24 July 2000; about day 70 of pregnancy) and stage of gestation was determined. The latter was translated into predicted lambing date (stage 1= 20$^{th}$ - 30$^{th}$ September, stage 2 = 1$^{st}$ - 10$^{th}$ October and stage 3 = 11$^{th}$ – 30$^{th}$ October). Ewe body condition score was recorded at scanning (CSP).

Blood samples were taken from all ewes two weeks prior to the start of lambing on the 7$^{th}$ September (about day 115 of pregnancy). Plasma β-hydroxybutyrate (β-OHB) concentration was measured. Ewes were scored for body condition (CSB) at this time. Ewe breeds were separated after blood sampling.

Lambing commenced on the 20th September 2000. When the lambs were ear-tagged at between 8 and 36 hours old, the date of parturition, litter size at tagging, total weight of the litter and Maternal Behaviour Score (MBS) were recorded.

A Maternal Behaviour Score (O'Connor *et al*., 1985) recorded for all dams was scored on a 5-point scale (low, 1 to high, 5) based on the distance a ewe retreats from her lambs when the shepherd is tagging them (Table 4.1).

*Table 4.1 The maternal behaviour scores at tagging and the number of dams with recorded MBS in this study.*

| Description of Maternal Behaviour Score (MBS)[1] | Original MBS[1] | Modified MBS | Coopworth dams (n) | EFCoop Dams (n) |
|---|---|---|---|---|
| Ewe flees at the approach of the shepherd, shows no interest in the lambs and does not return | 1 | 2 | 1 | 0 |
| Ewe retreats further than 10 metres but comes back to her lambs as the shepherd leaves them | 2 | 2 | 1 | 4 |
| Ewe retreats to such a distance that tag identification is difficult (5-10 metres) | 3 | 3 | 131 | 41 |
| Ewe retreats but stays within 5 metres | 4 | 4 | 74 | 30 |
| Ewe stays close to the shepherd during handling of her lambs | 5 | 4 | 10 | 3 |

[1] as described by O'Connor *et al*. (1985). n=number of animals.

The MBS scoring system has been used on this flock for over 25 years and ewes scoring an MBS of 1 have been culled annually. To determine the effect of MBS on lamb survival to weaning and weight of lamb weaned (refer to Table 4.5 and 4.6), MBS was modified as shown in Table 4.1. There was little variation in this trait, as reported in Chapter 3. Low subclass numbers for analyses involving MBS as a fixed effect in this study meant that dams with MBS of 1 and 2 were deleted from the data set and ewes with MBS 4 and 5 were combined into MBS 4. Ewes with an MBS 3 retreat to a distance that made ewe ear tag identification difficult whereas ewes with MBS 4 stay within 5m of the shepherd when her lambs are being tagged. Ewes with MBS 4 are considered better mothers.

Litter size at tagging and at weaning (9th January; mean lamb age 100 days) was recorded and litter survival was calculated from scanning to tagging and scanning to weaning by dividing the later litter size by the former litter size and it was recorded as a percentage. Weight of lamb weaned per ewe mated was recorded for each ewe. Ewes that lost an entire litter were included in the analysis as rearing zero kg of lamb to weaning. EFCoop and Coopworth ewes were run separately from prelambing through to weaning.

### 4.3.3 Statistical Analyses

Animal performance records were collected and used to generate data sets to enable breed and litter size comparisons using the MIXED procedure in SAS. PROC MIXED uses restricted/residual maximum likelihood (REML) methods to estimate the random effect (SAS, 2002). A univariate mixed linear model was fitted to test for the fixed effects of ewe breed, litter size (at scanning or birth) and the interaction between ewe breed and litter size. To help decide the pathways involved in the differences, analyses of covariance were performed and were retained in the model if statistically significant at $P<0.05$. The fixed effect interaction between ewe breed and litter size was only retained in the model if significant at $P<0.05$, unless otherwise noted.

The following linear model was used:

$$Y_{ijk} = \mu + A_i + L_j + AL_{ij} + A_i{*}\beta_1 X_{ijk} + e_{ijk}$$

where $Y_{ijk}$ is the record of the $k^{th}$ dam of the $i^{th}$ breed with the $j^{th}$ litter size,

$\mu$ is the general mean,

$A_i$ is the fixed effect of the $i^{th}$ breed,

$L_j$ is the fixed effect of the $j^{th}$ litter size,

$AL_{ij}$ is the fixed interaction effect of the $i^{th}$ breed and the $j^{th}$ litter size,

$X_{ijk}$ is the physiological trait measured (e.g.β-OHB, Ca, CSP, CSB, date of birth, age of ewe, litter weight at birth) in the $k^{th}$ dam of the $i^{th}$ breed with the $j^{th}$ litter size,

$\beta_1$ is the regression of the production trait of interest (e.g. weight of lamb weaned) on the physiological trait (e.g.β-OHB), and

$e_{ijk}$ is the random residual effect unique to $Y_{ijk}$.

Least squares means for the main factors affecting the trait of interest were estimated using SAS (SAS, 2002).

# 4.4 Results

## 4.4.1 Physiological Status of the Pregnant Ewe

Coopworth ewes had significantly higher body condition scores at pregnancy scanning and again at prelamb blood testing than EFCoop ewes, even though the ewes were run together up to blood testing (Table 4.2). However Coopworth ewes lost significantly more body condition through this period than EFCoop ewes and plasma β-OHB concentrations were significantly higher in Coopworth than EFCoop ewes prior to lambing (Table 4.2). There was no significant breed by litter size interaction for change in body condition score between pregnancy scanning and prelamb blood testing (P>0.05).

*Table 4.2 Pregnancy measurements by breed group (Coopworth and EFCoop ewes) (least squares mean ± standard error).*

| Pregnancy Trait | Coopworth Ewes (n= 432) | EFCoop Ewes (n=103) | P |
|---|---|---|---|
| CS at Pregnancy scanning (CSP) | 3.6 ± 0.03 | 3.2 ± 0.05 | **** |
| CS at Blood testing (CSB) | 3.2 ± 0.02 | 3.1 ± 0.05 | ** |
| CS Difference (CSB-CSP) | -0.35 ± 0.03 | -0.09 ± 0.06 | **** |
| β-OHB (mmol/l) | 0.65 ± 0.018 | 0.55 ± 0.032 | ** |

CS=body condition score.
ns = not significant; * P<0.05; ** P<0.01; *** P<0.001; **** P<0.0001.

Foetal number was a significant affect on body condition score at blood testing (P<0.05) but not at pregnancy scanning (P>0.05). Ewes carrying triplet litters had higher body condition scores prior to lambing than ewes carrying twins (3.2 ± 0.04 vs 3.1 ± 0.03). Ewes carrying twin lambs lost significantly more condition (-0.3 ± 0.04) than ewes carrying triplet litters (-0.1 ± 0.05) (P<0.001) however ewes carrying triplets (0.70 ± 0.03) had significantly higher β-OHB levels than ewes carrying twins (0.49 ± 0.02) (P<0.0001).

Age of dam significantly affected ewe condition score at pregnancy scanning (β=-0.04 ± 0.017, P<0.05), condition score at blood testing (β=0.04 ± 0.016, P<0.01) and change in body condition score over this period (β=0.06 ± 0.019, P<0.01).

The stage of pregnancy significantly affected ewe body condition score at blood testing (β=-0.11 ± 0.028, P<0.0001), change in condition score up to blood testing (β=-0.13 ± 0.038, P<0.001) and plasma β-OHB concentration (β=-0.09 ± 0.020). Ewes that were further through their pregnancy had lower condition scores, had a greater change in body condition since pregnancy scanning and had higher β-OHB plasma concentrations.

Plasma β-OHB concentration was significantly affected by change in body condition score ($P<0.001$) and ewes that lost condition had higher β-OHB levels ($\beta=-0.33 \pm 0.087$, $P<0.001$).

### 4.4.2 Physiological Effects on Dam MBS

There were significant breed by litter size interactions for MBS (Table 4.3). In Coopworth ewes MBS increased as litter size increased. MBS was the same for EFCoop ewes regardless of litter size. Coopworth ewes with triplet litters had significantly higher MBS than EFCoop ewes.

Factors significantly affecting MBS include age of dam ($\beta=0.14 \pm 0.025$, $P<0.0001$) and plasma β-OHB concentrations. Ewes with lower plasma β-OHB concentrations had higher MBS at tagging ($\beta=-0.30 \pm 0.10$, $P<0.01$). There was no significant β-OHB by breed and β-OHB by litter size interactions on MBS ($P>0.05$). Total litter weight did not significantly affect MBS ($P>0.05$).

*Table 4.3 The effect of MBS on Coopworth and EFCoop ewes with twin and triplet litters (least squares mean ± standard error).*

| Litter size | Coopworth Dams (n=432) | EFCoop Dams (n=103) | P (Breed) |
|---|---|---|---|
| All | 3.6 ± 0.04 | 3.4 ± 0.07 | * |
| Twins | 3.3 ±0.04 | 3.5 ± 0.08 | ns |
| Triplets | 3.8 ± 0.08 | 3.2 ± 0.11 | *** |
| P (Twins & Triplets) | **** | ns | |

MBS 1=poor, 5=excellent.
ns = not significant; * P<0.05; ** P<0.01; *** P<0.001; **** P<0.0001.

### 4.4.3 Dam Production

Coopworth dams (9.8 ± 0.16 kg) and EFCoop dams (9.9 ± 0.19 kg) had similar litter weights at parturition ($P>0.05$). Twin (8.8 ± 0.15 kg) and triplet litter weight (11.0 ± 0.20 kg) differed significantly ($P<0.0001$). There was no significant breed by litter size interaction. Older dams had heavier litters at birth ($\beta= 0.48 \pm 0.11$, $P<0.0001$).

Litter survival to tagging was significantly affected by the interaction between breed and litter size (P<0.01). EFCoop dams with triplet litters had lower litter survival rates to tagging whilst Coopworth litter survival to tagging was similar regardless of foetal number (Table 4.4). Litter weight at birth significantly affected survival to tagging (P<0.05).

Coopworth and EFCoop ewes had similar litter survival rates from scanning to weaning (Table 4.4). There was a non-significant interaction between litter size and breed (P>0.05). The survival of twin litters was greater than the survival of triplet litters (0.79 ± 0.03 vs 0.55 ± 0.035). Litter weight at birth had a significant effect on ewe litter survival to weaning ($\beta$=0.04 ± 0.012, P<0.0001).

*Table 4.4 The effect of ewe breed and litter size on litter survival from scanning (least squares mean ± standard error).*

| Scanned | Litter survival (proportion of litter to survive) | Coopworth Dams (n=480) | EFCoop Dams (n=115) | P (Breed) |
|---|---|---|---|---|
| All | To tagging | 0.89 ± 0.0167 | 0.79 ± 0.029 | ** |
| Twins | To tagging | 0.91 ± 0.015 | 0.90 ± 0.035 | ns |
| Triplets | To tagging | 0.86 ± 0.029 | 0.68 ± 0.045 | *** |
| | P (twins vs triplets) | ns | *** | |
| All | To weaning | 0.65 ± 0.029 | 0.68 ± 0.033 | ns |
| Twins | To weaning | 0.78 ± 0.038 | 0.80 ± 0.045 | ns |
| Triplets | To weaning | 0.52 ± 0.046 | 0.57 ± 0.051 | ns |
| | P (twins vs triplets) | **** | ** | |

ns = not significant; * P<0.05; ** P<0.01; *** P<0.001; **** P<0.0001.

When exploring the effect of MBS on litter survival, there was a significant interaction between breed, dam litter size and MBS (P<0.0001) (Table 4.5). Due to low subclass numbers dams with MBS 1 and 2 were deleted from the data set and ewes with MBS 4 and 5 were grouped into MBS 4. Litter survival rates were similar within litter size as MBS increased from 3 to 4 (Table 4.5).

*Table 4.5 The effect of maternal behaviour score on dam litter survival from tagging to weaning (least squares mean ± standard error).*

| Litter size | MBS | Coopworth Dams (proportion of litter to survive) | EFCoop Dams (proportion of litter to survive) | P (Breed) |
|---|---|---|---|---|
| Twin | 3 | 0.74 ± 0.029 (n=113) | 0.71 ± 0.057 (n=31) | ns |
| | 4 | 0.78 ± 0.045 (n=47) | 0.80 ± 0.064 (n=13) | ns |
| P (Twin) | | ns | Ns | |
| Triplet | 3 | 0.54 ± 0.073 (n=18) | 0.62 ± 0.089 (n=23) | ns |
| | 4 | 0.62 ± 0.051 (n=37) | 0.64 ± 0.097 (n=10) | ns |
| P (Triplet) | | ns | Ns | |

ns = not significant; * P<0.05; n=number of dams.

There were also significant fixed effect interactions between ewe breed, litter size and MBS ($P<0.05$) for weight of lamb weaned (Table 4.6). EFCoop dams with triplet litters with an MBS 3 at tagging went on to wean significantly more lamb weight per dam than Coopworth dam contemporaries. Coopworth dams with triplet litters differed significantly in that dams with an MBS 4 weaned nearly 10 kg more in lamb weight than Coopworth dams with an MBS of 3. Factors significantly affecting weight of lamb weaned were date of parturition ($\beta=-0.37 \pm 0.156$, $P<0.05$) and total litter weight at birth ($\beta=1.9 \pm 0.583$, $P<0.01$).

*Table 4.6 The effect of maternal behaviour score on weight of lamb weaned (kg) (least squares mean ± standard error).*

| Litter size | MBS | Coopworth Dams (weight (kg) weaned per ewe) | EFCoop Dams (weight (kg) weaned per ewe) | P (Breed) |
|---|---|---|---|---|
| Twin | 3 | 42.2 ± 1.21 kg (n=113) | 39.4 ± 2.37 kg (n=31) | ns |
| | 4 | 42.9 ± 1.85 kg (n=47) | 42.6 ± 2.49 kg (n=13) | ns |
| P (Twin) | | ns | ns | |
| Triplet | 3 | 42 ± 3.19 kg (n=18) | 52.4 ± 3.58 kg (n=23) | * |
| | 4 | 51 ± 2.13 kg (n=37) | 48.6 ± 3.76 kg (n=10) | ns |
| P (Triplet) | | * | ns | |

ns = not significant; * P<0.05; n=number of dams.

Coopworth dam triplet survival was lowest for dams with an MBS of 3 compared to dams with an MBS of 4 (Table 4.5). However this litter survival difference was not significant ($P>0.05$) but was of sufficient difference to explain the large difference in weight of lamb weaned (Table 4.6).

## 4.5 Discussion

New Zealand research indicates that ewes bearing multiples must be in good condition at parturition if their twins and triplets are to survive and grow to weaning (Geenty, 1997) and this study highlights the importance of maintaining ewe body condition over pregnancy.

Ewe-lamb bonding and lamb survival are maximised by management practices that increase the time spent at the birth site by the dam after parturition and ensure that the appropriate interactions occur between the dam and her lambs on the birth site (Nowak, 1996). Therefore it is imperative that feeding levels are sufficient not only at birth but also throughout pregnancy, to ensure that the ewe is not encouraged to travel from the birth site in search of food. Chapter 9 investigates the effect of pasture allowance during late pregnancy and at lambing on the strength of the ewe-lamb bond and subsequently lamb rearing performance for ewes with twin and triplet litters.

The energy cost of late pregnancy in the ewe is largely met by increased feed intake, except in very late pregnancy when intake may decline. The ewe may respond to increased nutrient demand in late pregnancy and lactation by eating more, by mobilisation of maternal tissue, by improving the overall effectiveness of overall digestion or by increasing the efficiency of utilisation of nutrients by tissues (Jelbart and Dawe, 1984). Ewes must utilise reserves to support the growth of multiples (Jelbart and Dawe, 1984). In this study Coopworth ewes mobilised more maternal tissue as observed in the change of body condition score and elevated plasma β-OHB levels over the same period and under the same management conditions compared to the EFCoop sheep. However, body condition scoring of ewes is a subjective measure indicating the condition held externally. From this procedure we are unable to determine if a ewe has substantial internal fat stores such as kidney knob and channel fat. Highly fecund breeds such as East Friesian and Finnish landrace and their crosses tend to distribute body condition differently maintaining a greater proportion of internal fat stores when compared to traditional breeds (Maijala, 1996).

In this study MBS varies with breed, litter size and plasma concentration of β-OHB. MBS gives an indication of a dam's degree of attachment to her lambs in the first days following parturition when challenged with human presence. Elevated levels of plasma β-OHB indicate that a ewe's nutritional demand is exceeding feed intake (Foot *et al.*, 1984). Pregnancy toxaemia (or 'sleepy sickness') is likely to occur in late pregnancy particularly in ewes carrying multiples and is due to underfeeding or stress (Geenty, 1997). Plasma concentration of β-OHB prior to lambing was significantly higher in ewes with lower maternal behaviour scores suggesting that a slight increase in plasma β-OHB concentration impairs a ewe's ability to bond effectively with her lambs, as shown by the lower MBS. Increased β-OHB levels may physiologically reduce the ewe's receptiveness to her lambs and may encourage the ewe to travel from the birth site in search of food which is likely to result in lambs becoming separated from their dam.

Litter survival and weight of lamb weaned was not influenced by the physiological affects of plasma β-OHB concentration. All ewes were in good condition with average scores between 3.1 and 3.2 in late pregnancy and under nutrition was not evident as indicated by plasma levels of β-OHB (Russell *et al*., 1967). However, ewes that lost body condition from day 70 to day 115 of pregnancy had elevated β-OHB levels and lower MBS.

Slightly elevated plasma β-OHB concentrations may be influencing litter survival in triplet litters. It is possible that elevated plasma β-OHB could be a mechanism reducing litter survival rates in highly fecund ewes. This may be because the size of the rumen is progressively restricted as gestation progresses due to abdominal space being restricted by the growth of multiple foetuses. If the pregnant ewe cannot eat enough and is required to graze continuously, she fails to utilise sufficient carbohydrates for energy and therefore mobilises maternal tissue to support the growing foeti. A reduction in ewe body condition is observed.

If we define mothering ability in a quantitative form such as the ability of a ewe to be able to rear its entire litter to weaning and wean her body weight in lamb, then the most important physiological factor affecting weight of lamb weaned was change in body condition score between mid and late gestation. The physiological effect of plasma β-OHB did not directly affect lamb production to weaning; however it did affect maternal behaviour as indicated by MBS. This study has shown that an increase in MBS can improve weight of lamb weaned for ewes with large litters. O'Connor *et al*. (1985) also observed an improvement in weight of lamb weaned per ewe mated with increasing MBS.

This study suggests that ewes that can maintain condition in late pregnancy provide a more suitable maternal environment to support and grow their litters. This is increasingly important for triplet litters. Chapter 3 also showed that ewes with triplets require more care than ewes with twins as temporary environmental effects account for nearly 90% of the total variation in lamb survival for triplets compared to 75% for twins. Temporary environmental effects, such as elevated plasma β-OHB levels arising from body condition loss influences a ewes maternal ability as indicated by MBS. A ewe that is physiologically stressed at a late stage in pregnancy may not be sufficiently receptive to the demands of her litter as ewes with higher β-OHB have lower MBS at tagging.

Many years of selection for maternal behaviour at tagging may have led to behavioural and physiological adaptations in the flock studied. Populations adapt to stressors because individuals who fail to adapt are relatively unsuccessful at contributing their genes to subsequent generations (Hargreaves, 1990). This is the case with performance-recorded ewes at Turnberry, poor mothers, as identified by the MBS system, are culled from the performance-recorded flock.

## 4.6 Implications

Selecting ewes for high fecundity increases the nutritional demand and magnifies the vulnerability to environmental stress, such as under nutrition in late pregnancy.

Ultrasound imaging for the early diagnosis of ewes with single, twin and triplet foetuses, is an excellent management tool. Diagnosis of foetal number (and stage of gestation) makes it possible to separate and preferentially treat those ewes with the greatest requirement. However, management systems need development to cater for high levels of ewe reproduction, in particular the nutritive and energy requirements of ewes with triplet litters from conception through to lamb weaning (see Chapter 9). This would enable improvement of biological and economic efficiency so that litter size at birth is translated into higher lamb output.

Measurement of plasma β-OHB concentration is of value when studying nutritional stress in grazing ewes during late pregnancy (Foot *et al.*, 1984). A series of blood samples leading up to parturition would be useful to determine whether plasma levels of β-OHB are rising, falling or static. However this is impractical under current farm management systems. Future technology may offer a solution, however in the interim we can monitor change in body condition in late pregnancy as an indicator of changing plasma β-OHB. We suggest that a sample of flock ewes of the same litter size are condition scored to give a representative condition score for the flock. A number of repeat measurements should be performed throughout pregnancy to give an indication of change in body condition and change in β-OHB. Informed feed management decisions can then be made.

The results from physiological studies should complement those from feeding studies. With strategic management such problems as pregnancy toxaemia, poor litter survival and reduced lamb growth rates can be reduced to ensure that lamb rearing ability and production are maximised. Optimum nutrition and subsequent ewe condition are important to ensure that genetic potential of the flock is achieved.

CHAPTER 5

# Lambing Performance of Finns and Texels

*Photographs taken by Julie Everett-Hincks*

# 5.0 Preamble

Previous results have shown that there was little variation in maternal behaviour score and lamb rearing performance in a commercially farmed Coopworth flock (Chapter 3). Breed differences are often regarded as indicative of genetic variation (Hinch, 1997). Therefore the study sought out sheep breeds that differed from traditional breeds in lamb survival and maternal ability. Anecdotal evidence from farmers suggested that the Finnish Landrace and Texel breeds differed from traditional breeds in these traits (Section 5.2). In 2001 an opportunity arose to study straightbred Finn and Texel 2-tooth primiparous ewes together on a commercial New Zealand sheep farm. A decision was made to investigate these recently introduced breeds to identify the lamb and ewe behaviours that encourage ewe-lamb bonding and enhance lamb survival.

In this part of the study the performance and behaviour of straightbred Finn and Texel ewes and their lambs was monitored to determine if there are any differences that could be used to improve lamb-rearing success across New Zealand flocks. Chapter 5 deals with reproductive and postnatal performance of Finns and Texels. Chapter 6 investigates post-parturient behaviour of Finns and Texels and relates post-parturient behaviour to lamb survival to weaning. Chapter 7 investigates the strength of ewe-lamb attachment at tagging and relates these behaviours to lamb survival to weaning.

# 5.1 Summary

The study was carried out on a commercial New Zealand sheep farm with performance recorded straightbred Finn and Texel primiparous ewes. The objective of the study was to investigate whether either of these breeds had particular traits of interest that could contribute to improved lamb rearing performance in the national sheep flock.

Litter size at birth was significantly higher for Finns than for Texels (2.0 and 1.2 respectively), however litter survival rates were similar between the two breeds. Texel litter weight at birth was heavier than for Finns, however Finn ewes weaned an additional 5.5 kg when compared with Texels.

Texel lambs had higher birth weights, weaning weights and growth rates when compared to Finn lambs, however lamb survival to weaning was similar. Dystocia was the predominant cause of death for Texel lambs whereas the starvation/exposure complex was the predominant cause of death for the smaller Finn lambs.

On this farm the Finn contributed to improved lamb production to weaning. Both breeds had low and similar lamb survival rates to weaning. Lamb wastage was greatest in the prolific breed and dystocia was a prevalent cause of lamb death in the meat breed. Both lamb losses and difficult births are unacceptable from an animal welfare perspective. Minimising lamb losses in both of these sheep breeds highlights the potential for improving profitability on farm. Crossbreeding is one option available to farmers to improve productivity, however crossbred performance requires investigation before crossbreeding can be exploited as a means of improving lamb rearing performance.

## 5.2 Introduction

In New Zealand, sheep farmers have a range of options to influence the genetic capability of their flock. New sheep breeds can improve lamb-rearing ability as crossbreeding is a quick and effective tool to improve fecundity and survival (Wiener *et al*. 1975; 1983). The main benefits of crossbreeding arise from complementarity; the manner in which two or more characteristics complement each other, and heterosis, the superiority in performance of the offspring over the average of the parents. Heterosis is greatest in characters most closely associated with the ability to survive and reproduce and the greater the genetic differences between two populations the greater the heterosis in crosses between them.

The performance of breeds chosen for crossbreeding is important for farmers to be able to make informed decisions. However there is little data for the Finn and Texel and therefore limited information on whether breed substitution offers advantages or whether crossbreeding can potentially improve productivity.

The Texel and Finnish Landrace (Finn) breeds of sheep were introduced to New Zealand in the 1990's. The Finn ewe has a mature weight ranging from 50-70kg and a lambing percentage ranging from 175 to 250%. It has been used in crossbreeding programmes with traditional sheep breeds, such as the Romney, to produce crossbred sheep with increased fecundity and resistance to facial eczema (Meadows, 1997). The Texel ewe has a mature weight of 50 to 65kg and has a lambing percentage ranging from 90 to 120%. The Texel is a meat breed and has been used widely in crossbreeding programmes throughout New Zealand (Meadows, 1997).

Differences have been observed between the performance and behaviour of Finn and Texel ewes and their lambs. Anecdotal evidence suggests that Texel lambs are extremely vigorous at birth and have higher survival rates. Breeders have stated at Field Days that lamb losses are as low as 10% from scanning to docking in Texels compared with the national flock average of 30% lamb losses over the same time period. Breeders also believe that Finn ewes employ communal lamb raising behaviour. The variation of mothering ability within and between breeds gives promise of scope for genetic improvement of this important characteristic (Manktelow, 1996), therefore the investigation of Finns and Texels warrants further investigation.

The objective of Chapter 5 was to investigate the performance of Finn and Texel ewes and lambs to weaning. Comparisons between Finn and Texel reproductive and postnatal performance were made.

## 5.3 Materials and Methods

### 5.3.1 Animals and Measurements

Straightbred Texel and Finn primiparous 2 year old ewes and their straightbred progeny were monitored intensively from mating through to lamb weaning in 2001. Approximately 100 ewes of each breed were included in the study.

The research was carried out on a commercial sheep farm that allowed access to both breeds and intensive monitoring throughout lambing. The animals included in the trial were fully performance recorded. One year of lambing data were included in the analyses.

Straightbred Finn rams were single sire mated to 18 month old Finn ewes from the 26th March to the 26th April (31 days). Straightbred Texel rams were joined with Texel ewes on the 23rd March and removed the 25th April (33 days). Mating harnesses were used and the raddle colour changed every ten-days. Trial ewes were pregnancy scanned on the 11th June and weighed on the 15th June.

Pre-mating weights were recorded on the 16th March. Pregnancy scanning weights were recorded 15th June (day 75 of pregnancy) and a pre-lamb weight was recorded 8th August. Weight change were calculated between each of these measurements; weight change early pregnancy (difference between mating and pregnancy scanning liveweight); weight change late pregnancy (difference between pregnancy scanning and lambing) and overall weight change from mating to lambing.

Mean lambing date was 31st August and 5th September for Finns and Texels respectively. Finn and Texel ewes were run separately pre and post lambing, however they were subject to the same feed and stock management.

Ewe litter size at birth and at weaning was recorded. Litter survival was measured from birth to weaning and was calculated by dividing litter size at weaning by litter size at birth and recorded as a percentage. Weight of lamb weaned per ewe mated was recorded for each ewe. Ewes that lost an entire litter were included in the analysis as rearing zero kg of lamb to weaning.

The maternal behaviour score (MBS) of each ewe was measured within 8 hours of birth on the basis of their response to the shepherd tagging their lambs on a 6-point scale from 1 (ewe leaves lamb and does not return) to 6 (ewe remains within 1m of lamb and makes physical contact with lamb) (score modified by O'Connor, 1996). The modified MBS was used in this study as it became apparent at the start of the trial that some ewes made contact with their lambs while their lambs were tagged by the shepherd. The 6-point score recorded this behaviour.

Lamb birth weight was recorded at tagging when the lamb was between 5 and 8 hours old. Lamb weight at weaning (16th January 2002) was recorded and lamb growth rate was calculated by subtracting birth weight from weaning weight and dividing by the number of days from date of birth until date of weaning. Growth rate was recorded in grams per day. Lamb survival was recorded at tagging and weaning. Lamb survival was recorded as a binary trait; those that survived were given a score of one while those that died were given zero.

Litter survival and lamb survival are treated as two separate but related traits. Litter survival is measuring a ewe's ability to rear all of her lambs while lamb survival is measuring an individual lamb's ability to survive.

Dead lambs were collected over lambing and sent for post mortem to determine time and cause of death. The following times of death were identified; ante parturient, parturient, immediate post parturient, delayed post parturient and late post parturient (Duff, 1981).

### 5.3.2 Animal Environment

The farm is located on the Takapau Plains, Hawkes Bay, New Zealand (40° South and 176° East). The average daily temperature throughout lambing was 11.2°C (min -1°C and max 22°C). The average daily rainfall for the lambing period was 1.3mm (maximum daily rainfall 48mm). The average wind speed recorded was 8km/hour (min 2km/hour, max 28 km/hour).

The ewes included in the study were set-stocked over 21.6 hectares at an average stocking rate of ten ewes per hectare throughout lambing. Finn ewes were set-stocked in paddocks; A, B and C. Texel ewes were set-stocked in paddocks D and E. Paddock residual pasture covers were recorded weekly throughout lambing and ranged from 600 to 1000 kgDM/ha at the start of the trial in early August. Residual pasture cover increased throughout the trial to reach between 1200 and 2000 kgDM/ha by mid September. Paddock contour was flat for all paddocks and each paddock had similar shelter.

### 5.3.3 Statistical Analyses

Animal performance records were collected and used to generate data sets to enable breed comparisons. Generalised Linear Model (GLM) procedures were used to analyse the data (SAS, 2002). Preliminary analyses were aimed at identifying which effects should be included in the linear models for the main analyses. Traits recorded before ewes were set-stocked prior to lambing, were compared using a simple linear model. Finn and Texel ewes were allocated separate paddocks prior to lambing so that their behaviour could be observed independent of the effects of the other breed. A nested design was used to analyse the performance traits from parturition. The following GLM model was used:

$$Y_{ijk} = \mu + A_i + B_{ij} + \beta X_{ijk} + e_{ijk}$$

where $Y_{ijk}$ is the record of the $k^{th}$ ewe of the $j^{th}$ paddock within the $i^{th}$ breed,

$\mu$ is the general mean,

$A_i$ is the fixed effect of the $i^{th}$ breed,

$B_{ij}$ is the random effect of the $j^{th}$ paddock nested within the $i^{th}$ breed,

$\beta$ is the regression of Y (e.g. weight of lamb weaned) on the covariate tested (e.g. litter weight at birth),

$X_{ijk}$ is the covariate tested (e.g. mating weight),

$e_{ijk}$ is the random residual effect unique to $Y_{ijk}$.

Least squares means for ewe and lamb breed were derived. Effects of variables such as birth weight, date of birth, ewe mating weight, litter size at birth and ewe weight change from pregnancy scanning to lambing and others referred to in section 5.3.1, were evaluated by including these as covariables in the model ($X_{ijk}$). Those with a significant effect on the dependant variable (e.g. weight of lamb weaned) were retained if significant at $P<0.05$.

Lamb post mortem data were analysed using chi-squared procedures.

## 5.4 Results

### 5.4.1 Ewe Pre-lambing Performance

Texel ewes were significantly heavier than Finn ewes at mating, pregnancy scanning and pre-lambing (Table 5.1). Mating weight had a significant effect on weight pre-lambing ($P<0.0001$). Heavier ewes at mating were heavier at lambing ($r=0.68$ for Finns and $r=0.80$ for Texels, $P<0.05$). Despite the difference in mating weight between the two breeds, 50% of all Finn ewes were mated in the first ten-day period compared to 28% of Texel ewes.

*Table 5.1 The effect of ewe breed on pre-lambing performance (least squares mean ± standard error).*

| Trait | Finns | Texels | P |
|---|---|---|---|
| Number of ewes | 91 | 98 | |
| | | | |
| Mating weight (kg) | 45.6 ± 0.51 | 51.6 ± 0.488 | **** |
| Pregnancy scanning weight (kg) | 43.6 ± 0.494 | 46.8 ± 0.481 | **** |
| Pre lambing weight (kg) | 49.1 ± 0.474 | 47.2 ± 0.638 | * |
| | | | |
| Weight difference early pregnancy[1] | -2.5 ± 0.287 | -4.3 ± 0.276 | **** |
| Weight difference late pregnancy[2] | 2.5 ± 0.309 | 1.8 ± 0.394 | ns |
| Weight difference from mating to lambing | 0.20 ± 0.474 | -1.7 ± 0.638 | * |

ns = not significant; * P<0.05; ** P<0.01; *** P<0.001; **** P<0.0001.
[1]Liveweight at mating subtracted from liveweight at pregnancy scanning.
[2] Liveweight at pregnancy scanning subtracted from liveweight prelambing.

Finn and Texel ewes lost weight in early pregnancy (Table 5.1). Texel ewes lost significantly more weight from mating to pregnancy diagnosis than Finns. Mating weight was a significant factor affecting weight change from mating through to pregnancy diagnosis ($\beta$=-0.17 ± 0.0381, P<0.0001), where heavier ewes at mating lost more weight in early pregnancy.

Texel ewes lost weight between mating and lambing whereas Finn ewes gained weight (Table 5.1). Mating weight ($\beta$=-0.17 ± 0.062, P<0.01) and litter size diagnosed at pregnancy scanning (P<0.0001) had significant effects on live weight change between mating and lambing. Heavier ewes at mating lost more weight up to lambing. Ewes with a single lamb lost 3.6 ± 0.423 kg, ewes with a twin litter lost 0.4 ± 0.493 kg and ewes with triplet litters gained 1.7 ± 1.015 kg.

### 5.4.2 Ewe Lamb Rearing Performance

Litter size at birth was significantly greater for Finns than for Texels, however litter size at weaning did not differ between breeds (Table 5.2). Therefore Finn ewes lost more lambs up to weaning. Both mating weight and weight change in early pregnancy significantly affected litter size at birth ($\beta$=0.05 ± 0.009, P<0.0001 and $\beta$=0.06 ± 0.017, P<0.001 respectively). The following factors had a significant effect on litter size at weaning: litter size at birth (P<0.0001), lamb birth weight ($\beta$=0.26 ± 0.071, P<0.001), ewe MBS (β=0.14 ± 0.054, P<0.05) and weight change in early pregnancy (β=-0.04 ± 0.023, P<0.05).

*Table 5.2 The effect of ewe breed on lamb rearing performance (least squares mean ± standard error).*

| Trait | Finns | Texels | P |
|---|---|---|---|
| Litter size at birth | 2.0 ± 0.067 | 1.2 ± 0.061 | **** |
| Litter size at weaning | 1.2 ± 0.115 | 0.8 ± 0.124 | ns |
| Litter weight at birth (kg) | 5.1 ± 0.182 | 6.0 ± 0.185 | * |
| Weight of lamb weaned per ewe (kg) | 27.5 ± 2.413 | 22.0 ± 2.453 | * |

ns = not significant; * P<0.05; ** P<0.01; *** P<0.001; **** P<0.0001.

Litter size at birth was greatest for Finn ewes however Texel ewes had heavier litter weights at birth. Texel ewes tended to have slightly heavier litters (P=0.06). The weight of lamb weaned per ewe differed between breeds. The following factors significantly affected weight of lamb weaned per ewe: litter size at birth (P<0.001), lamb birth weight (β=5.77 ± 1.908, P<0.01), ewe MBS (β=3.2 ± 1.264, P<0.05), pre-lambing live weight (β=0.76 ± 0.295, P<0.05) and weight change in early pregnancy (β=-1.11 ± 0.536, P<0.05). Ewes that had higher MBS at tagging weaned an additional 3.2 kg for each additional unit of MBS.

The average MBS for Finn ewes (2.5 ± 0.137) was significantly lower than for Texels (3.6 ± 0.128) (P<0.01) (Chapter 7 investigates the effect of MBS further).

### 5.4.3 Lamb Performance to Weaning

Lamb survival to tagging and weaning was not significantly different between breeds (Table 5.3).

Texel lamb birth weight was significantly higher than that recorded for Finn lambs (Table 5.3) and was significantly affected by litter size at birth (P<0.0001), ewe live weights pre-mating (β=-0.04 ± 0.015, P<0.01) and pre-lamb (β=0.09 ± 0.013, P<0.0001) and day of birth (β=0.03 ± 0.007, P<0.0001). Texel lamb weight at weaning was significantly higher than that for Finn lambs and was significantly affected by birth weight (β=3.09 ± 0.435, P<0.0001) and day of birth (β=-0.26 ± 0.051, P<0.0001) (Table 5.3). Factors significantly affecting lamb growth rate to weaning included: litter size at birth (P<0.05), birth weight (β=8.6 ± 3.81, P<0.05) and ewe weight change in late pregnancy (β=3.7 ± 1.174, P<0.01).

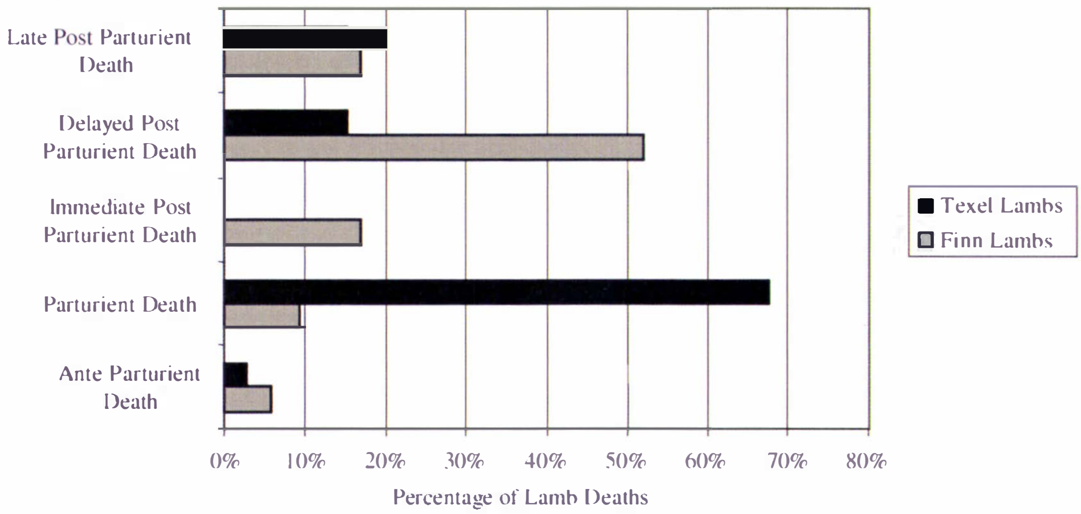
*Table 5.3 The effect of lamb breed on performance to weaning (least squares mean ± standard error).*

| Trait | Finns | Texels | P |
|---|---|---|---|
| Number of lambs | 158 | 121 | |
| Birth weight (kg) | 3.3 ± 0.08 | 3.9 ± 0.109 | * |
| Weaning weight (kg) | 22.2 ± 0.541 | 27.6 ± 0.662 | * |
| Growth rate to weaning (g/day) | 133 ± 4.075 | 177 ± 5.016 | * |
| Lamb survival from birth to tagging | 0.86 ± 0.075 | 0.70 ± 0.088 | ns |
| Lamb survival from birth to weaning | 0.67 ± 0.089 | 0.48 ± 0.105 | ns |

ns = not significant; * P<0.05; ** P<0.01; *** P<0.001; **** P<0.0001.

From post mortem analyses, time of death differed significantly between Finn and Texel lambs (P<0.05 (Figure 5.1). The predominant time of death for Finn lambs was delayed post-parturient (characteristic of starvation/exposure) whereas the predominant time of death for Texel lambs was at parturition (characteristic of dystocia). Time of lamb death did not differ significantly when comparing post mortem results of twin lambs from both breeds. The time of death for the majority of twin Finn and Texel lambs was delayed post parturient.

*Figure 5.1 Post mortem results for Finn and Texel lambs.*



## 5.5 Discussion

To eliminate any effects of previous lambing experience only primiparous ewes were observed under similar farming conditions. Poor maternal behaviour in primiparous ewes is often considered a cause of lamb death (Arnold and Morgan, 1975). Lamb survival rates to weaning were low and similar for primiparous Finn and Texel ewes in this study. Litter size was significantly higher for Finns than for Texels (2.0 and 1.2 respectively) and Finns weaned greater lamb weights than Texels (27.5kg versus 22kg), however litter weight at birth and litter survival to weaning was similar for the two breeds. Holmes (1976) reported similar findings for Finn ewes observing that they produce litters of light lambs and that "few survive without optimum physical and social conditions". He also suggested that Finn ewes showed dysepimelesis and observed that the highly active lambs were successful at locating the teat but that they were generally ineffective at suckling. Perinatal behaviour of Finns and Texels was investigated in Chapter 6.

Overseas information suggests that at the same litter size and ratio of lamb birth weight to mature size, more prolific sheep such as Finns have higher lamb viability and lower optimum birth weights (Gama *et al*., 1991). In this study Finns were noted for their poor lamb survival, however their lower litter weights at birth translated into greater weight of lamb weaned compared to Texels.

Finn lambs are born with little fat cover and very fine fleece, making them prone to exposure even up to two weeks after birth (Cook, 1996). However, Finn crosses appear to have higher lamb survival than pure Finns (Geenty, 1997). The predominant cause of lamb death in Texels was dystocia as a result of relative foetal oversize. Dalton *et al.* (1980) also reported that the most frequent causes of death were dystocia among singles and starvation exposure among multiples.

The farm manager attempted to subject Finn and Texel ewes to the same management treatment from mating through to lambing. However it appears that Finn ewes require less feed compared with Texel ewes to maintain live weight throughout pregnancy. Texel ewes lost more weight in the early stages of pregnancy when compared with Finn ewes. Finn ewes gained weight in the later stages of pregnancy and consequently on average gained weight throughout pregnancy while the Texel ewe lost weight. Despite this dystocia was the predominant cause of death for Texel lambs. It is important to remember that foetal weight is included in the ewe live weight. Finn ewes were 2kg heavier than Texels prior to lambing, however Texel ewe litter weight at birth was nearly 1kg heavier than Finns.

Good ewe nutrition is essential for optimum birth weights of multiple lambs. Placental development is especially important in ewes lambing 150% or more to ensure lambs are sufficiently heavy at birth to minimise deaths from starvation/exposure. Ideally ewes with multiple foetuses should be identified as early as possible, separated and preferentially fed (Geenty, 1997).

Selection of sheep that produce lambs with a good ability to survive and thrive requires more attention. Crossbreeding is one of the tools that successful farmers can adopt, however crossbreeding and the resulting heterosis cannot remedy the results of poor feeding or breeding (Anon, 1998).

## 5.6 Conclusions

Litter size at birth was significantly higher for Finns than for Texels (2.0 and 1.2 respectively), however litter survival rates were similar between the two breeds. Texel litter weight at birth was heavier than for Finns, however Finn ewes weaned an additional 5.5 kg when compared with Texels.

Introduction of prolific breeds do not contribute to substantial increases in weight of lamb weaned through increased litter size. Heavier birth weights observed in Texels may not contribute to increased vigour if lamb birth weights are excessively large enough to cause dystocia particularly in maiden ewes. We cannot assume that good mothering ability is closely associated with prolificacy, particularly for Finns. Holmes (1976) also observed reduced mothering ability in Finns. He suggested that the reduced 'maternal drive', could have arisen through lack of selection pressure associated with selection for prolificacy and from the high degree of husbandry.

Investigation of the performance of the F1 progeny resulting from a Finn Texel regular cross is required to determine if these breeds combined can improve lamb-rearing ability to weaning through exploitation of complementarity and heterosis.

# CHAPTER 6

# The effect of ewe and lamb post-parturient behaviour on lamb survival to weaning: A comparative study of Finns and Texels

*Photograph taken by Julie Everett-Hincks*

Related publications:

Everett-Hincks *et al*. (2004). The effect of ewe and lamb post-parturient behaviour on lamb survival to weaning: A comparative study of Finns and Texels. *Submitted to the New Zealand Society of Animal Production.*

## 6.1 Summary

Post parturient behaviours of Finn and Texel ewes and their lambs were monitored under commercial conditions and a relationship sought between this and lamb survival to weaning.

The time interval between the birth of the first and second born twin lamb was longer for Texels, allowing Texel ewes to bond more effectively with their first born before the birth of the second twin. Texel ewes with twins were observed for longer.

Texel lamb survival to weaning was greatest when Texel ewes quickly made contact with their lamb following birth (within 2 minutes) and for lambs that located their dam's udder within 30 minutes from birth. Finn lamb survival to weaning was improved when Finn lambs were more vocal after birth, when Finn ewes showed less flocking behaviour as indicated by MBS and where Finn ewes spent a greater proportion of time grooming their lambs.

Variation in perinatal behaviour within and across breeds was large and therefore potential exists for improving the ability of the ewe and lamb to bond successfully at parturition by selecting for some of the behaviours identified in this study that encourage lamb survival to weaning.

## 6.2 Introduction

Lamb mortality is regarded as a major constraint to efficient sheep production in New Zealand (Geenty, 1997). Dysepimelesis, or lack of maternal care, of ewes producing large litters may be an important factor contributing to high lamb mortality both at birth and up to weaning (Holmes, 1976).

The first hour post-partum is the most important in the establishment of an exclusive mother-young bond (Alexander *et al.*, 1986) and the behaviour of the ewe before, during and after parturition has a major influence on lamb survival (Nowak, 1996).

The behaviour of both the young and the mother is important and failure of the lamb and ewe to interact properly can result in lamb death and a reduction of profit to the farmer (O'Connor and Lawrence, 1992a). Maternal behaviour at parturition is critical to lamb survival (O'Connor *et al.*, 1985; Astroshi and Osterberg, 1979). Poindron *et al.* (1980b) emphasised the importance of lamb behaviour and reported that the behaviour of the neonatal lamb influences the maternal responsiveness of the ewe. However Dwyer and Lawrence (1999a) reported that the ewe shows only a small responsiveness towards behavioural changes in her lamb and that ewe attachment behaviours are controlled by intrinsic factors and are insensitive to the lamb.

Some studies have demonstrated breed differences in perinatal ewe behaviour and neonatal lamb behaviour (Dwyer and Lawrence, 1999a; Fahmy *et al.*, 1996) but studies investigating ewe and lamb behaviour conjointly are scarce and research involving ewe lambing at pasture is even more infrequent as objective behavioural studies at parturition require a high labour input (Cloete *et al.*, 2002). Little is known about the maternal behaviour of highly fecund sheep and even less is known of maternal behaviour of those sheep under New Zealand farming conditions. The majority of research to date cannot be related to New Zealand sheep farming conditions as husbandry practices here differ. Field research is limited with the majority of outdoor studies performed on Merinos, which are not naturally fecund.

This study was carried out in 2001 to identify any behaviour and performance differences between straightbred primiparous Finn and Texel ewes and their lambs under commercial conditions. Anecdotal evidence suggested that there were some phenotypic differences in the behaviour and performance of Finns and Texels (see Chapter 5). Holmes (1976) observed that Finn ewes were more interactive in frequency and variety of encounters in group lambing where they were observed licking alien lambs and Finn lambs would suck colostrum from alien ewes immediately post-partum.

The aim of this study was to monitor the behaviour of Finn and Texel ewes and their lambs immediately after birth and relate these behaviours to lamb survival to weaning. Chapter 7 investigates the strength of ewe-lamb attachment at tagging and relates these behaviours to lamb survival to weaning. Chapter 7 also investigates the relationship between post-parturient and tagging behaviours.

# 6.3 Materials and Methods

## 6.3.1 Animals and Measurements

The behaviour of straightbred Texel and Finn primiparous 2 year old ewes and their straightbred progeny were monitored at parturition in 2001. Approximately 100 ewes of each breed were included in the study which was carried out on a commercial sheep farm. Individual litter size was known prior to lambing, as ewes had been pregnancy scanned at about day 75 of pregnancy.

The two breeds were separated for the duration of the study (from the 8$^{th}$ of August to the 30$^{th}$ of September) (see Chapter 5). Ewes were set-stocked at ten ewes per hectare and were observed under pastoral grazing conditions. Finn and Texel ewes were separated prior to lambing so that their behaviour could be observed independent of the effects of the other breed. Paddocks had similar residual pasture cover, degree of shelter and contour.

Two shepherds monitored the ewes on foot between 7am and 6pm daily for two weeks prior to lambing to allow the ewes to become habituated to human presence and throughout lambing. Ewes had been previously ear-tagged so that they could be individually identified from a distance and binoculars were used if necessary.

Only a few animals were observed at parturition (Table 6.1). Ewes with triplets were excluded from the analyses due to insufficient numbers as were ewes assisted by the shepherd at birth. Half of the Texel ewes with a single lamb required assistance with parturition (Appendix 6.9).

*Table 6.1 Number of animals included in analyses.*

| | Number of animals at Parturition | | Number of animals alive at Weaning | |
|---|---|---|---|---|
| | Finns | Texels | Finns | Texels |
| Total Number of ewes | 20 | 19 | 19 | 19 |
| Number of ewes with litter size 1 | 8 | 10 | 7 | 10 |
| Number of ewes with litter size 2 | 12 | 9 | 12 | 9 |
| | | | | |
| Total number of lambs | 32 | 28 | 14 | 25 |
| Lambs from litter size 1 | 8 | 10 | 4 | 9 |
| Lambs from litter size 2 | 24 | 18 | 13 | 16 |

Perinatal behaviour data were collected in the field from a distance of approximately 20m. Close observation during daylight hours ensured that the parturition process could be predicted and subsequently observed and recorded. The observation period commenced from expulsion of the first lamb to 30 minutes after the last of the litter was born. The observation period varied depending on litter size and the time taken between births of twin lambs. The total recording period for ewes having a single lamb was 30 minutes, however for ewes having twins this time varied and was dependant on the time taken between expulsion of the first and second twin (Table 6.4, Figure 6.1). Date of parturition and paddock were recorded for each ewe and time of parturition was recorded for each lamb.

For ewes having twin litters, observations were recorded for three periods:

- First born; before the birth of the second twin lamb (FB),
- Second born; for 30 minutes from expulsion (SB), and
- First born; from expulsion of the second twin lamb (FB when SB).

The observation time for single lambs and for second-born twin lambs was 30 minutes. The observation time differed between first born twin lambs and was dependent on the time taken for the ewe to give birth to the second twin (Table 6.4).

The ewe behaviours recorded were, time to first contact lamb, time spent grooming lamb and the frequency of sniffing the lamb, withdrawing, butting, facilitating sucking and preventing sucking. Lamb behaviours recorded were, time from expulsion to stand, locate the udder and suck from the ewe. Frequency of bleats was also recorded. The definitions of ewe and lamb behaviours are described in Table 6.2.

*Table 6.2 Definitions of ewe and lamb behaviours recorded after birth.*

| Behaviour | Description |
|---|---|
| 1. Ewe behaviours | |
| Lamb contact | Time from birth to first physical contact with lamb (nose the lamb). |
| Grooming [DL] | Licking and nibbling of the lamb. |
| Sniffing/Nosing [DL] | Ewe touches the lamb with her nose, but does not groom. |
| Facilitates sucking [DL] | Ewe crouches turns one leg out to aid lamb sucking. |
| Prevents sucking [DL] | Ewe moves as the lamb moves to udder and attempts to suck. Ewe movements include: circling, backing or forward movements. |
| Withdrawing [DL] | Ewe moves back directly from the lamb at her head (2+ steps). |
| Butting [DL] | Ewe pushes lamb down or away with downwards, sideways or forward movements of her head. |
| Abandonment/rejection [DL] | Ewe does not groom the lamb, leaves the lamb soon after birth, butts the lamb if approaches, frequently accompanied by high-pitched bleating. |
| High-pitched ewe bleats | Made with the mouth open and by ewes when they are separated from their lambs. |
| Low-pitched ewe bleats | Made with the mouth closed and when the ewe is in close proximity to the lamb. Sometimes referred to as 'rumble' calls. |
| 2. Lamb behaviours | |
| Stands [DL] | Lamb supports itself on all four feet for at least five seconds |
| To udder [DL] | Lamb's head nudging ewe in udder region. Lamb standing. |
| Successful suck [DL] | Lamb standing and has teat in mouth, appears to be sucking for at least 5 seconds. |
| Bleats | The number of bleats was recorded for each lamb. |

[DL] as described by Dwyer and Lawrence (1999a).

Physical markings were used to identify individual twin lambs during the observation period. At the end of the observation period lambs were spray marked so that first born (FB) and second born (SB) lambs could be identified from their tag number and monitored to weaning (16$^{th}$ January, 2002) (Appendix 6.8). This also ensured that parentage was 100% accurate because the lambs were permanently identified at ear tagging, approximately 8 hours after birth.

The maternal behaviour score (MBS) of each ewe was determined at the end of the observation period on the basis of their response to the shepherd spray marking their lambs (Table 6.3) (score modified by O'Connor, 1996).

*Table 6.3 Description of the maternal behaviour score used in this study after parturition.*

| Description of the Maternal Behaviour Score (MBS) | MBS |
|---|---|
| Ewe flees as the shepherd approaches, shows no interest in lambs and does not return | 1 |
| Ewe retreats further than 10 metres, comes back to her lambs as the shepherd leaves | 2 |
| Ewe retreats to such a distance that tag identification is difficult (5-10 metres) | 3 |
| Ewe retreats but stays within 5 metres | 4 |
| Ewe stays close to the shepherd during handling of her lambs | 5 |
| Ewe makes contact with her lambs while they are being handled by the shepherd | 6 |

The MBS is normally evaluated when lambs are between 12 and 24 hours old, however in this study the MBS was evaluated twice, at the end of the observation period after birth and when the lambs were between 5 and 8 hours old at tagging (Chapter 7).

Lamb birth weight and sex were recorded at tagging (Chapter 7). Lamb survival in this study was recorded from parturition to weaning. Lambs that survived to weaning were given a score of '1' and lambs that died were given a score of '0'.

Lambs were weaned on the $16^{th}$ of January 2002. Their growth rate was calculated by subtracting birth weight from weaning weight and dividing it by the number of days from birth to weaning. Growth rate was recorded in grams per day.

Lamb birth weight, weaning weight and growth rate were analysed separately for lambs observed at parturition (Appendix 6.8). The differences between first and second born twins were determined.

## 6.3.2 Statistical Analyses

This study is a simple comparison between breeds as the number of ewes and lambs restricted the rigour of statistical analyses that could be applied. The statistical model used in Chapter 6 and Chapter 7 differs from that used in Chapter 5. Analyses in Chapter 5 showed that the effect of paddock nested within breed was not significant for production traits measured from birth and therefore the statistical model was modified. Within and across breed analyses were performed for all ewes and their lambs (Table 6.1). Order of birth was fitted for twin litters to detect differences in behaviour and performance between first (FB) and second born (SB) lambs.

Differences between breeds within litter size (and order of birth for twin litters) for continuous behaviour traits and lamb performance traits were tested using PROC MIXED which uses restricted/residual maximum likelihood (REML) methods to estimate the random effect (SAS, 2002). The following simple univariate mixed linear model was fitted to test for the fixed effects of ewe breed, litter size (at birth or order of birth for twins) and the interaction between ewe breed and litter size.

The following linear model was used:

$$Y_{ijk} = \mu + A_i + L_j + AL_{ij} \ \beta_1 X_{ijk} + e_{ijk}$$

where $Y_{ijk}$ is the record of the k[th] dam of the i[th] breed with the j[th] litter size,

$\mu$ is the general mean,

$A_i$ is the fixed effect of the i[th] breed,

$L_j$ is the fixed effect of the j[th] litter size,

$AL_{ij}$ is the fixed interaction effect of the i[th] breed and the j[th] litter size,

$X_{ijk}$ is the trait measured (e.g. lamb birth weight, ewe liveweight, pasture cover) in the i[th] breed of the j[th] litter size,

$\beta_1$ is the regression of the trait of interest (e.g. MBS) on the covariable (e.g. lamb birth weight, ewe liveweight), and

$e_{ijk}$ is the random residual effect unique to $Y_{ijk}$.

The covariance structure of the data was modelled using the REPEATED and GROUP options where the heterogenous variance structure of breed was specified. Least squares means for the main factors affecting the trait of interest were estimated.

Behaviours that occurred infrequently, or were performed by relatively few animals were analysed using Chi-squared tests. PROC CATMOD (SAS, 2002) was used to analyse categorical dependent behaviour traits (e.g. 0 = did not high-pitch bleat, 1 = did high-pitch bleat) and lamb survival to weaning (0= dead and 1 = alive). Weighted least square estimates for the fixed effects of breed and litter size at birth and the interaction between breed and litter size were derived by Chi-squared procedures ($\chi^2$).

The LIFETEST procedure (SAS, 2002) was used to compute and plot the distribution estimate of ewe and lamb time related behaviours after parturition, such as ewe-lamb contact time, time for lamb to stand, locate the udder and suck. These behaviour observations are skewed and right-censored due to the termination of the experiment (i.e. thirty minutes after lamb birth). This analysis procedure correctly uses the censored observations as well as the non-censored. The LIFETEST procedure generates a survival distribution function (SDF) and is used in this case to describe the behaviour times.

The SDF evaluated at time (*t*) (i.e. 30 minutes) is the probability that a lamb of a particular breed and litter size will have a 'behaviour' time exceeding *t*, that is:

S(t) = Pr(T>t),

where S(*t*) denotes the survival distribution function and T is the behaviour time of a randomly selected lamb. The cumulative distributive functions for each of the behaviour traits are graphically plotted and are defined as 1-S(*t*), that is the probability that a behaviour time does not exceed *t* (i.e. 30 minutes). To determine whether the curves plotted are homogenous across breeds and or litter sizes (and order of birth) (P>0.05), PROC LIFETEST provides two rank tests (log-rank and Wilcoxon). The Wilcoxon test places more weight on early times and the log-rank test places more weight on longer times. The association between covariates and the behaviour time variable were investigated using the Wilcoxon Test and reported if significant at P<0.05. The covariate tests are pooled across treatments and it is not possible to calculate the directional effect the covariate is having on the dependent variable.

# 6.4 Results

## 6.4.1 Ewe and Lamb Behaviour

Mean lambing day was the 31st August 2001 for Finn ewes and the 3rd September for Texels (Table 6.4). Twinning Texel ewes lambed significantly later than their Finn counterparts and later than Texel ewes with a single lamb (Table 6.4).

*Table 6.4 Lambing day according to litter size, time between the birth of first and second born lambs for twinning ewes and observation period for Finn and Texel ewes included in this study (least squares mean ± standard error).*

| | Finns | Texels | P |
|---|---|---|---|
| Lambing day of year | (31st Aug) 242 ± 1.9 | (3rd Sept) 245 ± 1.8 | ns |
| Lambing day for litter size 1 | (30th Aug) 241 ± 2.8 | (30th Aug) 241 ± 2.4 | ns |
| Lambing day for litter size 2 | (1st Sept) 243 ± 2.4 | (8th Sept) 250 ± 2.5 | * |
| P (Litter size 1 and 2) | ns | * | |
| Time between birth of first and second born twin (hours) | 0.24 ± 0.05 | 0.70 ± 0.24 | * |
| Recording time for litter size one (hours) | 0.5 | 0.5 | |
| Recording time for litter size two (hours) | 0.74 ± 0.14 | 1.21 ± 0.16 | * |

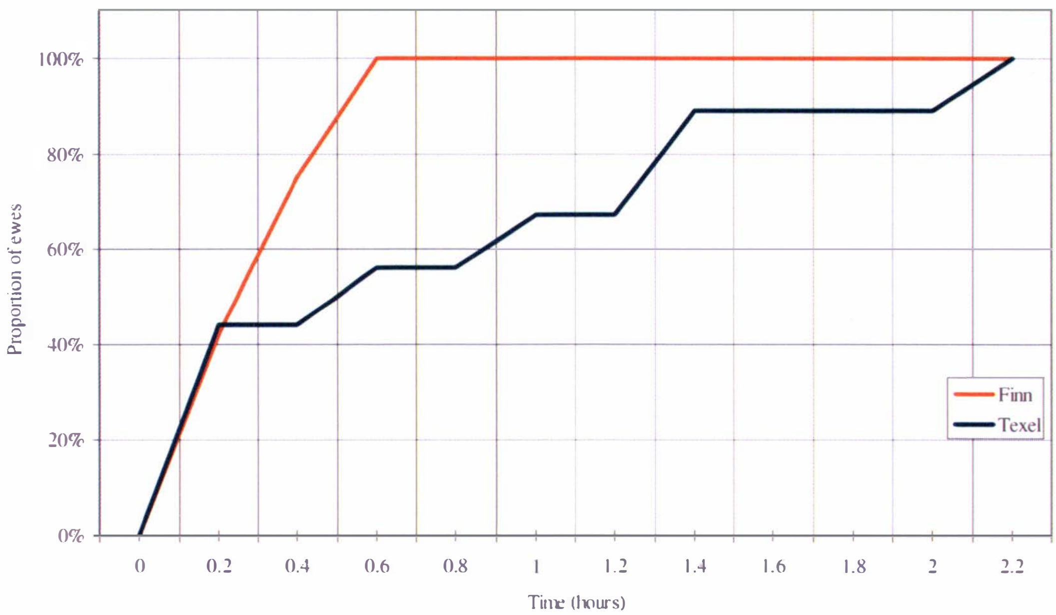
ns=not significant; * P<0.05; ** P<0.01; *** P<0.001; **** P<0.0001.

The mean observation period (recording time) differed for twinning Finn (44 minutes) and Texel (73 minutes) ewes. Time between the birth of the first (FB) and second born

(SB), was significantly longer for Texels than for Finns (43 minutes compared with 14 minutes) (Table 6.4).

A comparison of cumulative distributions for Texels and Finns is shown in Figure 6.1. All Finn ewes had given birth to twin litters within 35 minutes from the birth of their first lamb (FB). The time between births was significantly longer for Texel ewes (Wilcoxon mean 0.70 ± 0.24 hours) than Finn ewes (Wilcoxon mean 0.24 ± 0.05 hours) (Log-Rank P<0.10).

*Figure 6.1 The effect of breed of ewe on the time between twin lamb births.*




Texel ewes were quicker to contact their single lamb after birth and a greater proportion of Texel ewes had made contact ten minutes after birth (Table 6.5, Figure 6.2). Finn ewes were quicker to make contact with their first-born twin lamb and all first-born lambs had ewe contact within 3 minutes from birth compared to 80% of Texels (Figure 6.2). Texel ewes with twin litters were quicker to contact their second born twin than their first-born. All second born Texel twin lambs had ewe contact 2 minutes after birth compared with 80% of first born lambs (Figure 6.2).

Cumulative distributions were similar between breeds for time to stand, locate and suck from their dam's udder (Table 6.5, Figure 6.3, 6.4, 6.5). The means, presented in Table 6.5 show that it takes Finn and Texel lambs about 10-15 minutes to stand from birth, a further 5 minutes to locate the udder and an additional 10 minutes to suck from their dam. Day of birth and ewe weight change in early pregnancy significantly affected time for single lambs to stand and ewe weight change over pregnancy also affected time for the first born twin to stand (P<0.05). Lambs took longer to stand after birth if their dam gained weight in pregnancy. The effect of day of birth affected time for single lambs to locate their ewe's udder, whereas ewe weight change over pregnancy affected the first born twins time to locate the udder (P<0.05) and lamb sex affected the second born twin's time to locate the ewe's udder (P<0.05). First born twin lambs took longer to locate their dam's udder if their dam gained weight in pregnancy.

*Table 6.5 The effect of breed on ewe and lamb behaviour after birth (Wilcoxon mean ± standard error).*

| Behaviour | Litter size | Finn | Texel | Wilcoxon P | Log-Rank P |
|---|---|---|---|---|---|
| Ewe-lamb contact time (minutes) Figure 6.2 | Single | 11 ± 4.8 | 2 ± 1.07 | ns | 0.10 |
| | Twin FB | 0.6 ± 0.28 | 1.8 ± 0.87 | ns | ns |
| | Twin SB | 0.9 ± 0.32 | 0.4 ± 0.18 | ns | ns |
| Time to stand (minutes) Figure 6.3. | Single | 10.5 ± 3.27 | 16.5 ± 3.36 | ns | ns |
| | Twin FB | 13 ± 2.67 | 16 ± 2.52 | ns | ns |
| | Twin SB | 14.5 ± 3.74 | 13 ± 1.17 | ns | ns |
| Time to locate udder (minutes) Figure 6.4 | Single | 20 ± 3.77 | 15 ± 2.79 | ns | ns |
| | Twin FB | 16 ± 2.02 | 16 ± 0.87 | ns | ns |
| | Twin SB | 15 ± 3.94 | 19 ± 2.32 | ns | ns |
| Time to suck Figure 6.5 | Single | 28 ± 3.04 | 26 | ns | ns |
| | Twin FB | 21.5 ± 4.09 | 53 ± 17.34 | ns | ns |
| | Twin SB | 22 ± 7.18 | 16.6 | ns | ns |

ns=not significant at P<0.05; * P<0.05; ** P<0.01; *** P<0.001; **** P<0.0001.

*Figure 6.2 The effect of breed on the proportion of single and twin lambs to have ewe contact within ten minutes from birth.*

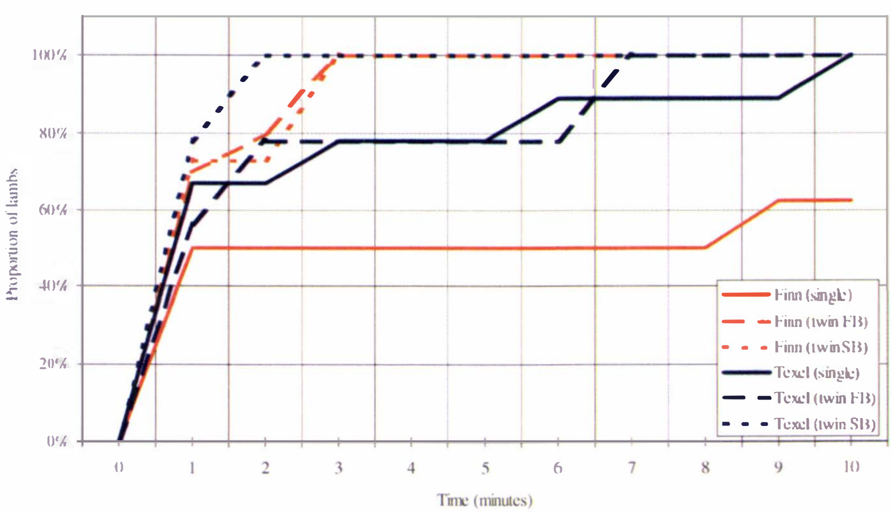


*Figure 6.3 The effect of breed on the proportion of single and twin lambs to stand within thirty minutes from birth.*

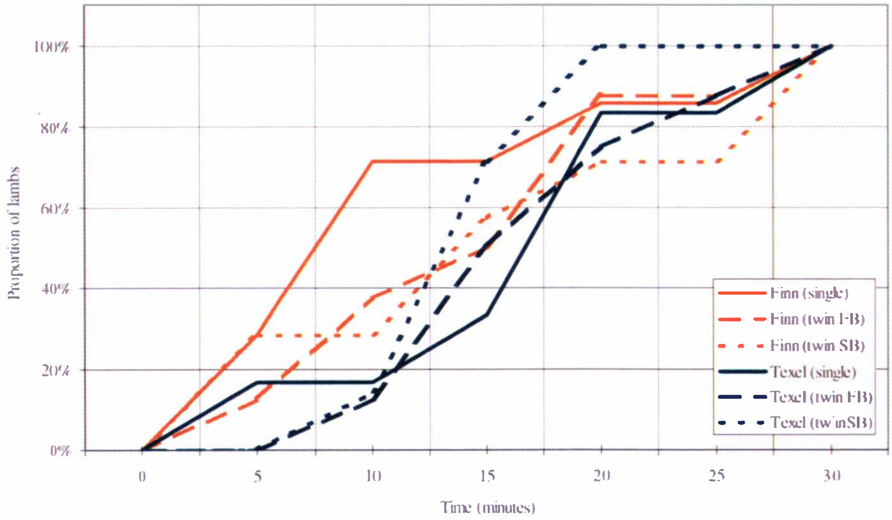



*Figure 6.4 The effect of breed on the proportion of single and twin lambs to locate their ewe's udder thirty minutes after birth.*

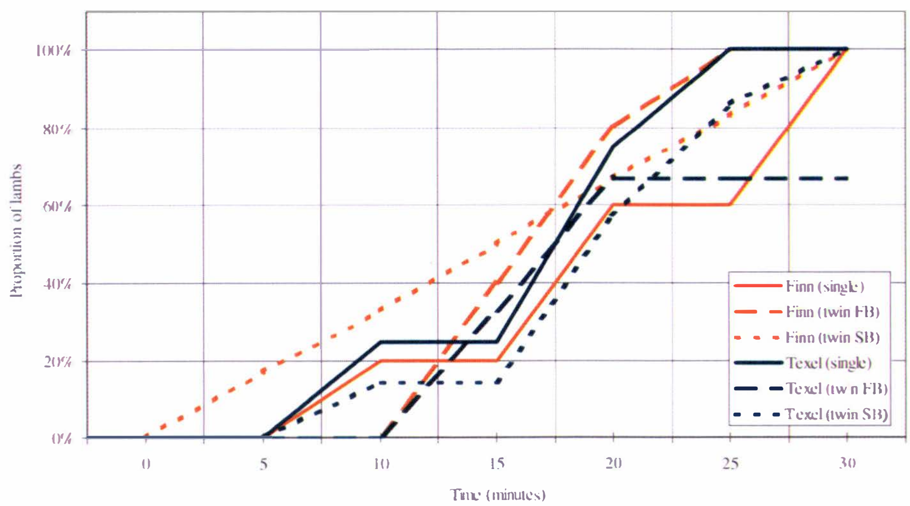
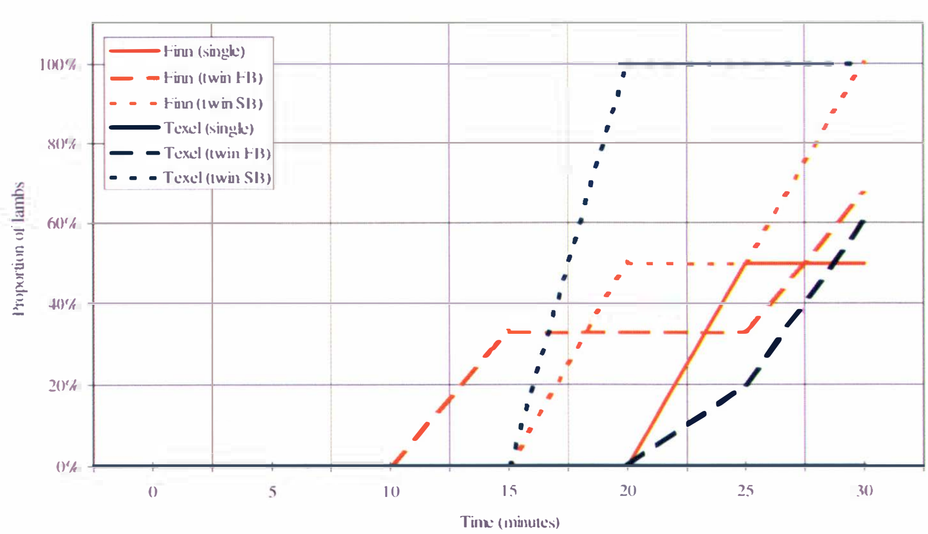



*Figure 6.5 The effect of breed on the proportion of single and twin lambs to suck from their ewe's udder thirty minutes after birth.*

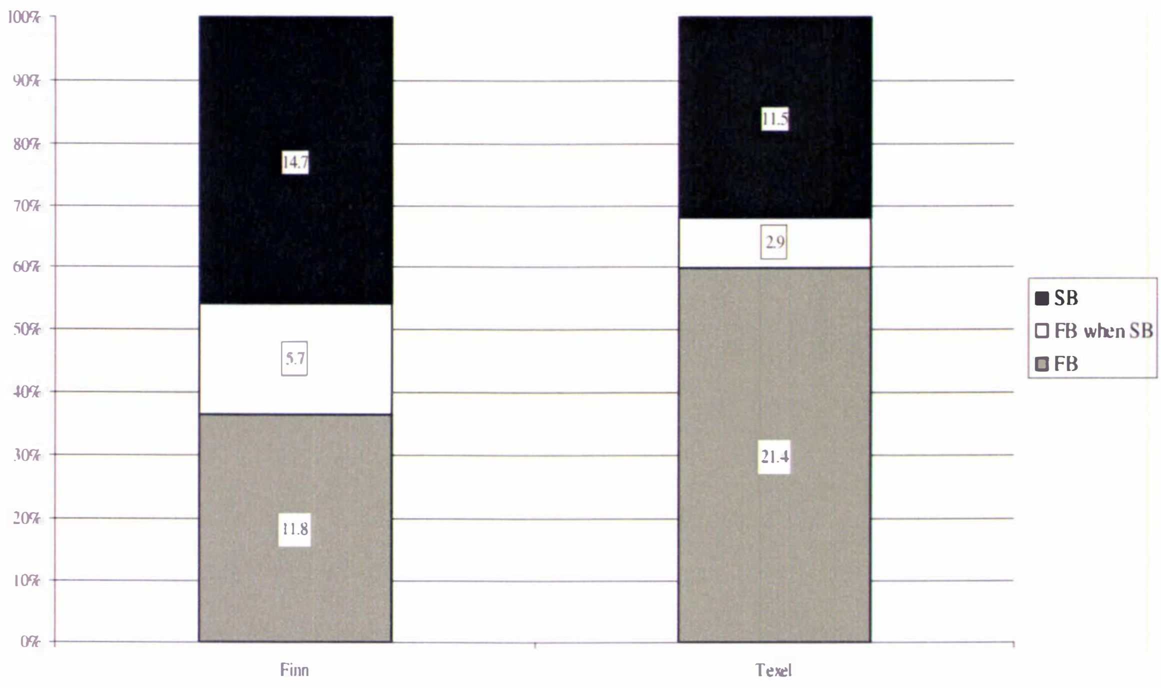


Ewe behaviour was similar for Finns and Texels with a single lamb, except Texel ewes sniffed their single lamb a greater number of times in the 30-minute observation period (Appendix 6.7).

Finn and Texel ewes significantly reduced the amount of time grooming their first-born lamb when their second lamb was born and significantly groomed their second born lamb more (Appendix 6.7 and Figure 6.6). Texel ewes groomed their first-born twin lamb longer than Finn ewes, however the total observation time was shorter for twinning Finn ewes (Table 6.4).

Texel twin lambs bleated a greater number of times than Finn lambs. First-born Finn lambs bleated significantly more following the birth of the second twin (Table 6.6). High bleating frequency was similar between ewe breeds (Table 6.6).

*Figure 6.6 The effect of ewe breed on time spent grooming twin lambs.*




Number in histogram represents grooming time in minutes.

*Table 6.6 Lamb and ewe bleating behaviour after birth (least squares mean ± standard error).*

| | Litter Size | Finns | Texels | P (Breed) |
|---|---|---|---|---|
| Lamb bleats (tally) | Single | 25 ± 15.09 | 47 ± 13.386 | ns |
| | Twin FB | 8 ± 9.688 | 60 ± 23.36 | * |
| | FB when SB | 35 ± 9.688 | 26 ± 23.36 | ns |
| | SB | 10 ± 9.276 | 62 ± 23.36 | * |
| P (FB when SB & SB) | | ns | ns | |
| P (FB & FB when SB) | | * | ns | |
| Proportion of ewes to | Single | 14% | 10% | ns |
| High pitch bleat | Twins | 18% | 0% | ns |
| P (singles and twins) | | ns | ns | |
| Low ewe bleats (tally) | Single | 123 ± 101 | 82 ± 84 | ns |
| | Twins | 300 ± 80 | 333 ± 89 | ns |
| P (singles and twins) | | ns | * | |

ns=not significant at P<0.0.05; * P<0.05; ** P<0.01; *** P<0.001; **** P<0.0001.

Texel ewes facilitated sucking their first-born twin a greater number of times than Finn ewes. However, Finn ewes tended to increase this behaviour on arrival of the second twin (Appendix 6.7, Table 6.7.1). Finn ewes with a single lamb never butted their lamb, however a small number of Texel ewes with singles did (Appendix 6.7, Table 6.7.1). This may have been a direct effect of increased birth weight and increased birthing problems, however due to an insufficient number of observations this analysis of covariance was not performed. No ewes butted their second born lamb, however a small proportion of Finn and Texel ewes butted their first born following the birth of the second twin. A small proportion of Finn ewes abandoned their single lamb at birth. No ewes abandoned their twin lambs during the observation period (Appendix 6.7).

Maternal behaviour score after birth significantly increased as litter size increased for Finns but not for Texels, however mean MBS for Texels was greater than that for Finns (Table 6.7).

*Table 6.7 The effect of ewe breed and litter size on maternal behaviour score after birth (least squares mean ± standard error).*

| Litter Size | All | Finns | Texels | P (Breed) |
|---|---|---|---|---|
| All | | 3.3 ± 0.294 | 4.6 ± 0.153 | *** |
| Single | 3.7 ± 0.243 | 2.7 ± 0.444 | 4.7 ± 0.197 | *** |
| Twins | 4.2 ± 0.226 | 3.9 ± 0.385 | 4.6 ± 0.235 | ns |
| P | ns | * | ns | |

ns=not significant at P<0.05; * P<0.05; ** P<0.01; *** P<0.001; **** P<0.0001.

## 6.4.2 Relationship Between Behaviour and Lamb Survival

This section compares postnatal behaviour of lambs that survived to weaning to those that did not. The timed behaviours for twin lambs are presented in Table 6.8 and Figures 6.7 through to 6.9. The timed behaviours for single lambs are presented in Table 6.8.2 (Appendix 6.8).

Ewe-lamb contact time after birth was similar for Finns regardless of whether the lamb survived to weaning or died (Table 6.8, Figure 6.7). Texel ewe-lamb contact time was significantly longer for lambs that did not survive to weaning with only 50% ewe-lamb contact made in the first 2 minutes after birth compared to nearly 100% in those that survived to weaning (Table 6.8, Figure 6.7).

Time for the twin lamb to stand after birth was not significantly related to survival to weaning (Table 6.8, Figure 6.8). Texel lambs that did not locate the udder within thirty minutes from birth did not survive to weaning (Figure 6.9). Time taken for Finn lambs to locate their ewe's udder did not significantly affect survival to weaning (Table 6.8, Figure 6.9).

*Table 6.8 The effect of behaviour after parturition on twin lamb survival to weaning (Wilcoxon mean ± standard error).*

| Behaviour | Breed | Died | Survived | Wilcoxon P | Log-Rank P |
|---|---|---|---|---|---|
| Ewe-lamb contact time (minutes) Figure 6.7 | Finn | 0.4 ± 0.23 | 0.9 ± 0.29 | ns | ns |
| | Texel | 4.2 ± 2.25 | 0.7 ± 0.37 | ns | * |
| Time to stand (minutes) Figure 6. 8 | Finn | 16 ± 3.5 | 12 ± 3.13 | ns | ns |
| | Texel | 17 ± 5.29 | 14.5 ± 1.56 | ns | ns |
| Time to locate udder (minutes) Figure 6.9 | Finn | 19 ± 2.72 | 12 ± 2.33 | ns | ns |
| | Texel | na | 19 ± 1.73 | ns | ns |

ns=not significant at P<0.05; * P<0.05; ** P<0.01; *** P<0.001; **** P<0.0001.

*Figure 6.7 The effect of ewe-lamb contact time on twin lamb survival to weaning.*

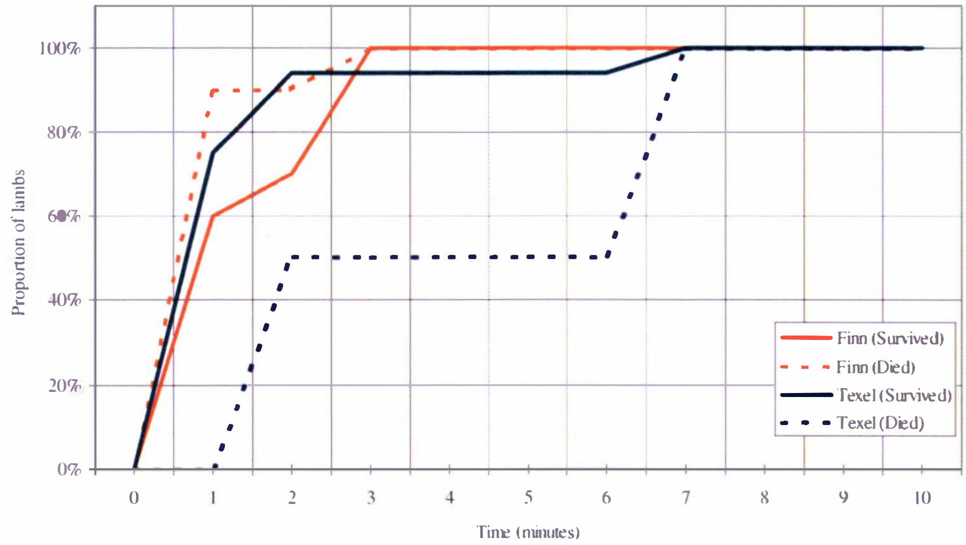



*Figure 6.8 The effect of twin lamb stand time on lamb survival to weaning.*

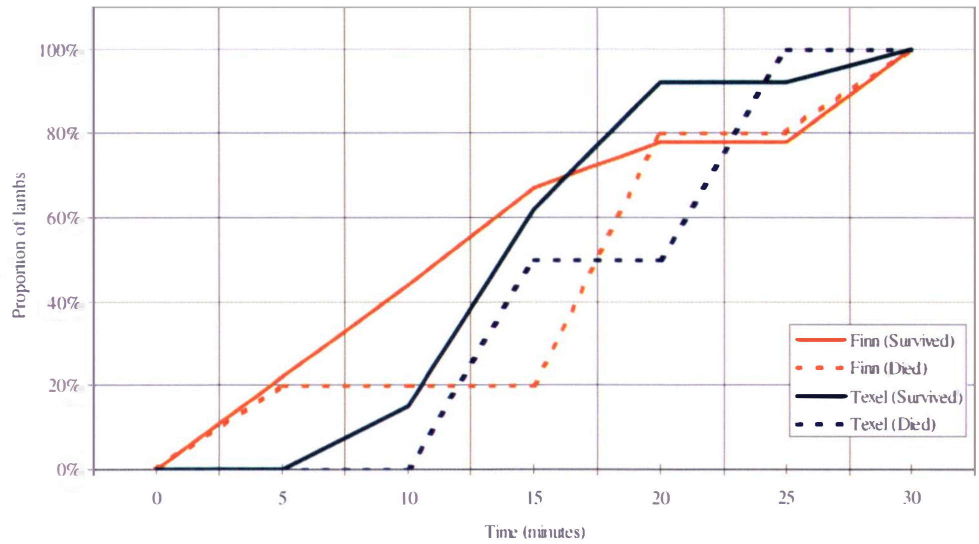
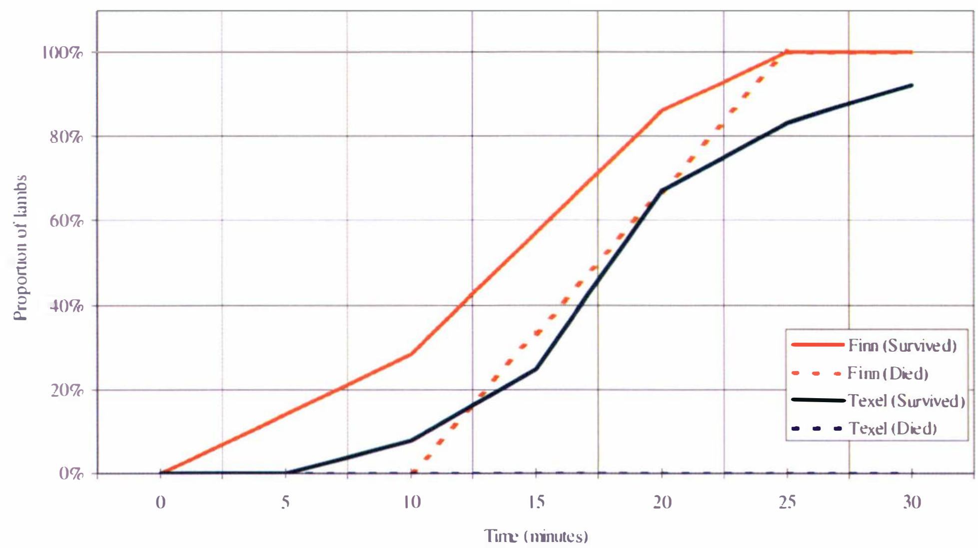



*Figure 6.9. The effect of time to locate ewe's udder on twin lamb survival to weaning.*



Grooming time did not significantly differ between breed, within litter size and between surviving lambs and lambs that died before weaning (Table 6.9). Finn twin lambs that did not survive to weaning bleated significantly less after birth compared to twin Texel lambs that died (Table 6.10). Finn ewes with surviving single lambs had higher MBS than their Texel contemporaries (P<0.10) (Table 6.11).

*Table 6.9 The effect of ewe grooming time on lamb survival to weaning (least squares mean ± standard error)*

| Ewe Litter size | Breed | Died | Survived | P |
|---|---|---|---|---|
| Single | Finns | 5 ± 7.15 | 22 ± 6.19 | ns |
| | Texels | 22 ± 12.38 | 15 ± 4.13 | ns |
| | P (Breed) | ns | ns | |
| Twins | Finns | 34 ± 5.3 | 26 ± 9.18 | ns |
| | Texels | 18 ± 11.24 | 41 ± 6.01 | ns |
| | P(Breed) | ns | ns | |

ns=not significant at P<0.05; * P<0.05; ** P<0.01; *** P<0.001; **** P<0.0001.

*Table 6.10 The effect of lamb bleating frequency on lamb survival to weaning (least squares mean ± standard error).*

| Ewe Litter size | Breed | Died | Survived | P |
|---|---|---|---|---|
| Single | Finns | 33 ± 25 | 19 ± 22 | ns |
| | Texels | 22 ± 44 | 49 ± 14.5 | ns |
| | P (Breed) | ns | ns | |
| Twins | Finns | 24 ± 30 | 135 ± 49 | ns |
| | Texels | 200 ± 61 | 133 ± 32 | ns |
| | P(Breed) | * | ns | |

ns=not significant at P<0.05; * P<0.05; ** P<0.01; *** P<0.001; **** P<0.0001.

*Table 6.11 The effect of ewe MBS on lamb survival to weaning (least squares mean ± standard error).*

| Ewe Litter size | Breed | Died | Survived | P |
|---|---|---|---|---|
| Single | Finns | 2.0 ± 0.53 | 3.3 ± 0.53 | ns |
| | Texels | 4.0 ± 0.92 | 4.8 ± 0.31 | ns |
| | P (Breed) | ns | * | |
| Twins | Finns | 3.6 ± 0.29 | 4.3 ± 0.38 | ns |
| | Texels | 4.0 ± 0.46 | 4.8 ± 0.29 | ns |
| | P(Breed) | ns | ns | |

ns=not significant at P<0.05; * P<0.05; ** P<0.01; *** P<0.001; **** P<0.0001.

## 6.5 Discussion

The time interval between the birth of the first and second born twin lamb was longer for Texels, allowing Texel ewes more time to bond with their first born before the birth of the second twin. Fahmy *et al*. (1996) reported a shorter time interval between births of lambs for prolific sheep compared to non-prolific sheep. Texel ewes with twin litters were observed for a significantly longer period than Finn ewes.

The perinatal behaviours associated with the formation of the ewe-lamb bond, particularly ewe-lamb contact and grooming differed between Finns and Texels in this study. Finn ewes appeared to contact their first born twin quicker after birth than Texel ewes. A number of Finn ewes gave birth to their lambs standing up possibly enabling them to make contact with their lamb sooner than the majority of Texel ewes who lay on their side to give birth. Unfortunately the posture while giving birth was not recorded.

The time to stand, locate the udder and suck were similar for twin Finn and Texel lambs. All Finn and Texel lambs had stood within thirty minutes from birth, the majority of lambs had located their ewes udder in this time and over 60% of all lambs had sucked from their dam. A New Zealand study at Ruakura on mixed age Romney ewes concluded that the time taken by a lamb to stand up after birth was regarded as the best available indication of vigour (Wallace, 1949). Wallace (1949) found that about 30% of the lambs stood within 15 minutes of birth and within thirty minutes over 70% had stood. He observed no relationship between vigour and lamb sex, type of birth, age of ewe and birth weight. Astroshi and Osterberg (1979) observed that an increase in birth weight shortened the time from birth to standing. This study showed no significant relationship between birth weight and time to stand from birth.

Wallace (1949) observed that lambs most commonly suck for the first time, from half to one hour after birth and suggested that twin lambs tend to be slower to suck than single lambs. Single Finn lambs were slower to suck from their dam than twin lambs and the first born Texel lamb appeared to take even longer. O'Connor and Lawrence (1992a) reported that neither ewe grooming behaviour nor general lamb activity were directly related to time to first suck. Finn ewes increased behaviours to facilitate sucking in their first born twin following the birth of the second twin whereas Texel ewes reduced preventative sucking behaviours to their first twin following the birth of the second twin.

Texel ewes groomed their first born twin for an additional ten minutes before the birth of the second twin when compared to Finns. The post parturient ewe becomes attached to and distinguishes any newly born lamb, which she has licked for 20-30 minutes (Smith *et al*., 1966). Finn and Texel single lambs and second born twins were observed for thirty minutes and their dam spent nearly half of that time grooming. There are conflicting views on how ewes of prolific breeds divide their grooming attention between litter members. Owens and Armstrong (1985) suggested that Booroola ewes distribute their grooming attention to all lambs regardless of birth order, whilst Holmes (1976) and Astroshi and Osterberg (1979) reported a progressive reduction in the time Finn sheep spent grooming each successive lamb in the litter. However in this study grooming time was evenly split between Finn twin lambs whereas the second born Texel lamb received less grooming. O'Connor *et al*. (1992b) observed for Scottish Blackface sheep the second born twins receive less grooming and O'Connor *et al*. (1992b) observed the birth of the second born twin resulted in a dramatic reduction in grooming of the first born twin. They also observed that twin bearing ewes show some enhancement in grooming activity, however individual twin lambs received less grooming overall than singles. This study showed a similar trend in the grooming behaviour of twin lambs, however individual Finn twin lambs received the same amount of grooming as Finn single lambs.

The licking of the lamb accompanied by low-pitched bleating appears to be instinctive (Smith, 1965). The ewes in this study had high low-pitch bleating frequencies and it has been suggested by Dwyer *et al*. (1998b) that the low-pitched bleat rate of dams may be a reflection of her intrinsic physiology and the higher rate in primiparous ewes may reflect her inexperience, immaturity and therefore slower bond formation. They also suggested that low-pitch bleating rate is unaffected by lamb bleating behaviour. Pollard (1992) suggested that the rate of lamb vocalisations may affect dam bleating behaviour. Nowak (1996) suggests that vocal communication between the ewe and the lamb is central to adequate bond formation and has demonstrated that lamb bleating behaviour is involved in the attachment process. Lamb vocalisations are modified by their rearing experience and appear to represent a signal of need (Dwyer *et al.*, 1998b). Finn first born twin lambs significantly increased their bleating on the arrival of the second twin whereas Texel lambs did not. However Texel lambs did bleat significantly more times than Finn lambs. In this study, lamb bleating does appear to signal need and is used to encourage attention from the dam. However the reason for seeking attention differs for the two breeds investigated in this study; flocking behaviour is strongest for Finns and maternal behaviour may have been compromised by increased incidence of difficult births for Texels.

There were more inappropriate behaviours, such as butting and withdrawing, in Texel ewes with a single lamb. This may be a consequence of a large proportion of Texel ewes needing assistance with parturition. The rate of withdrawing was similar for first and second born twins for both breeds, however Dwyer and Lawrence (1998a) observed that the rate of withdrawing following the birth of the second of a pair of twin lambs was significantly less than following the birth of the first twin. Dwyer and Lawrence (2000) noticed a reduction in the frequency of rejection behaviours with experience, with more rejecting behaviours expressed by ewes in their first parity. Primiparous ewes were investigated in this study and their behaviour was not investigated in subsequent parities to determine if rejection behaviours decreased with experience.

Finn lambs that were less vocal after birth were less likely to survive to weaning. Texel lambs bleated significantly more frequently than Finns on all occasions, and Texel ewe behaviours such as time to contact their twin lamb were important for survival to weaning. Lindsay *et al.* (1990) also concluded that increased vocal behaviour of lambs was strongly associated with earlier recognition of their mother and better bonding. Time spent grooming was significantly lower for Finn ewes that lost a single lamb. It is highly likely that Finn ewes, because of their lower MBS, became separated from lambs that were less vocal. Finn ewes appeared more mobile and had lower MBS than Texel ewes. Lindsay *et al.* (1990) observed that the best mothers were those that were less active in stressful situations and those that bleated more often. Holmes (1976) found reduced maternal ability in Finn ewes compared to Forest Clun ewes and suggested that the poorer maternal ability could have arisen through a lack of selection pressure associated with selection for prolificacy and from the high degree of husbandry, as Finn sheep in Europe are predominantly lambed indoors. He recommended that Finn ewes require considerably greater shepherding than other breeds at lambing to achieve their production potential. This recommendation may be suitable for intensive farming practices as experienced in Europe and the UK, however in New Zealand less human interference may encourage more effective ewe lamb bonding and reduce the chance of ewe-lamb separation and subsequently lamb death in Finns. Alternatively, Texel ewes require increased shepherding to reduce lamb and ewe deaths from dystocia.

Variation in perinatal behaviour within and across breeds was large and therefore potential exists for improving the ability of the ewe and lamb to bond successfully at parturition by selecting for some of the behaviours identified in this study that encourage lamb survival to weaning. This requires knowledge as to whether these behaviours show genetic variation and whether easily managed indicator traits are available to assist with selection. The existence of between breed variation is suggestive that these behaviours are under some genetic influence.

This study and general observations at lambing in 2001 do not support the anecdotal evidence that suggested Texel lambs are more vigorous at birth and that Finn ewes employ communal lamb raising behaviour.

## 6.6 Conclusions

The following post-parturient behaviours were the most effective indicators of survival to weaning:

- Texel lambs that locate their ewe's udder within 30 minutes from birth have a significantly improved chance of survival to weaning.
- Texel ewes that quickly make contact with their lamb following birth (within 2 minutes), improved the lamb's chance of survival to weaning.
- Finn ewes that show less flocking behaviour as indicated by MBS, were more likely to produce surviving lambs at weaning.
- Finn ewes that spend a greater proportion of time grooming their lamb improve its chance of survival to weaning.
- Vocal Finn lambs have an improved chance of survival.

Dwyer and Lawrence (2000) suggest that the behaviour of a primiparous ewe is reasonably predictive of her behaviour in subsequent pregnancies, therefore potential exists for improving the ability of the ewe and lamb to bond successfully at parturition by selecting for some of the behaviours identified in this study that encourage lamb survival to weaning.

Published estimates of genetic (co)variances in literature are scarce as neonatal behaviour is difficult to measure (Cloete *et al*., 2002). Cloete *et al*. (2002) showed that time to stand from birth and time to suck from standing do have a genetic component and that it differs between breeds.

Breeding programmes designed to increase the number of lambs born per ewe mated should take into consideration the mother-offspring social relationship and employ selection criteria and management practices to improve ewe-lamb bonding. However before this can be done effectively more research is required to identify a behavioural indicator that is easy to measure under New Zealand farming conditions and has a significant genetic component. Chapter 7 investigates behaviours at tagging as potential indicators for lamb rearing performance and Chapter 8 uses the arena behaviour test to predict maternal behaviour.

## 6.7 Appendix: Ewe Post-Parturient Behaviour

*Table 6.7.1 Ewe behaviour following parturition (least squares mean ± standard error).*

| | Litter Size | All | Finns | Texels | P (Breed) |
|---|---|---|---|---|---|
| Sniff (Tally) | Single | | 1.4 ± 0.869 | 7.5 ± 3.249 | ns |
| | Twin FB | 9.2 ± 8.41 | 13 ± 16.671 | 5.6 ± 2.175 | ns |
| | FB when SB | 5.4 ± 8.41 | 4.5 ± 16.671 | 6.3 ± 2.175 | ns |
| | SB | 17.5 ± 8.41 | 32 ± 16.671 | 2.8 ± 2.175 | ns |
| P (FB when SB & SB) | | ns | ns | ns | |
| P (FB & FB when SB) | | ns | ns | ns | |
| Grooming time (minutes) | Single | | 14.7 ± 5.384 | 15.4 ± 3.779 | ns |
| | Twin FB | 16.6 ± 2.243 | 11.8 ± 2.282 | 21.4 ± 3.862 | * |
| | FB when SB | 4.3 ± 2.243 | 5.7 ± 2.282 | 2.9 ± 3.862 | ns |
| | SB | 13 ± 2.2.43 | 14.7 ± 2.282 | 11.5 ± 3.862 | ns |
| P (FB when SB & SB) | | ** | ** | ns | |
| P (FB & FB when SB) | | *** | ns | ** | |
| Facilitate sucking (tally) | Single | | 2.7 ± 1.459 | 1.7 ± 1.065 | ns |
| | Twin FB | 4 ± 1.591 | 0.2 ± 0.987 | 8 ± 3.026 | * |
| | FB when SB | 3.5 ± 1.591 | 3.1 ± 0.987 | 3.9 ± 3.026 | ns |
| | SB | 2.1 ± 1.591 | 2.4 ± 0.987 | 1.8 ± 3.026 | ns |
| P (FB when SB & SB) | | ns | ns | ns | |
| P (FB & FB when SB) | | ns | * | ns | |
| Prevent sucking (tally) | Single | | 2.6 ± 1.445 | 4.1 ± 2.178 | ns |
| | Twin FB | 5.6 ± 1.932 | 2.9 ± 3.387 | 8.3 ± 1.859 | ns |
| | FB when SB | 4.9 ± 1.932 | 7.3 ± 3.387 | 2.4 ± 1.859 | ns |
| | SB | 3.3 ± 1.932 | 5 ± 3.387 | 1.6 ± 1.859 | ns |
| P (FB when SB & SB) | | ns | ns | ns | |
| P (FB & FB when SB) | | ns | ns | * | |
| Did Withdraw (>or=1) | Single | | 28.5% | 50% | ns |
| (proportion of ewes) | Twin FB | 24% | 33% | 11% | ns |
| | FB when SB | 24% | 33% | 11% | ns |
| | SB | 24% | 25% | 22% | ns |
| P (Twin lambs) | | ns | ns | ns | |
| Did Butt (>or=1) | Single | | 0% | 10% | ns |
| (proportion of ewes) | Twin FB | 5% | 8% | 0% | ns |
| | FB when SB | 10% | 8% | 11% | ns |
| | SB | 0% | 0% | 0% | nc |
| P (Twin lambs) | | ns | ns | ns | |
| Did Abandon | Single | | 14% | 0% | ns |
| | Twin FB | 0% | 0% | 0% | nc |
| (proportion of ewes) | FB when SB | 0% | 0% | 0% | nc |
| | SB | 0% | 0% | 0% | nc |
| P (Twin lambs) | | nc | nc | nc | |

ns=not significant at P<0.05; * P<0.05; ** P<0.01; *** P<0.001; **** P<0.0001.

## 6.8 Appendix: Lamb Production Traits

Lamb production is reported separately for lambs included in this behaviour study and makes comparisons between first and second born twin lambs as well as breed comparisons (Table 6.8.1).

Single lamb production was similar between breeds. However differences were evident in twin born lambs. Generally first-born lambs were heavier at birth than their second born twin, regardless of breed (P=0.06). First-born Texel lambs were ½ kg heavier than their twin (Table 6.8.1). Ewe mating weight, birth day and ewe liveweight change in early pregnancy all had a significant effect on lamb birth weight (P<0.05). Texel lamb survival to weaning was higher than for Finns, however these analyses excluded Texel ewes that had difficulty lambing. Texel twin lambs in this study had higher growth rates and weaning weights than Finns (Table 6.8.1).

*Table 6.8.1 Performance of Finn and Texel lambs observed after birth (least squares mean ± standard error).*

| | Litter Size | All | Finns | Texels | P (Breed) |
|---|---|---|---|---|---|
| Lamb birth weight (kg) | All Singles | | 4.6 ± 0.22 | 4.5 ± 0.15 | ns |
| | All Twins | | 2.9 ± 0.15 | 3.8 ± 0.222 | * |
| | First born | 3.5 ± 0.13 | 3 ± 0.18 | 4.1 ± 0.269 | ** |
| | Second born | 3.2 ± 0.13 | 2.9 ± 0.18 | 3.5 ± 0.269 | ns |
| P (First, second born) | | ns | ns | * | |
| Lamb survival to weaning | All Singles | | 50% ± 0.186 | 90% ± 0.12 | ns |
| | All Twins | | 48% ± 0.115 | 89% ± 0.073 | ** |
| | First born | 62% ± 0.095 | 45% ± 0.158 | 78% ± 0.104 | ns |
| | Second born | 75% ± 0.098 | 50% ± 0.166 | 100% ± 0.104 | ** |
| P (First, second born) | | ns | ns | ns | |
| Growth rate (g/day) | All Singles | | 186 ± 36.59 | 189 ± 8.149 | ns |
| | All Twins | | 118 ± 11.28 | 165 ± 8.73 | ** |
| | First born | 138 ± 10.32 | 101 ± 15.95 | 174 ± 13.09 | ** |
| | Second born | 145 ± 9.85 | 136 ± 15.95 | 155 ± 11.54 | ns |
| P (First, second born) | | ns | ns | ns | |
| Lamb weaning weight (kg) | All Singles | | 29 ± 4.882 | 32 ± 1.215 | ns |
| | All Twins | | 20.8 ± 2.008 | 24.7 ± 1.168 | ns |
| | First born | 21.9 ± 1.592 | 18.3 ± 2.795 | 25.4 ± 1.839 | * |
| | Second born | 23.7 ± 1.563 | 23.4 ± 2.769 | 23.9 ± 1.446 | ns |
| P (First, second born) | | ns | ns | ns | |

ns=not significant at P<0.05; * P<0.05; ** P<0.01; *** P<0.001; **** P<0.0001.

*Table 6.8.2 The effect of behaviour after parturition on single lamb survival to weaning (Wilcoxon mean ± standard error).*

| Behaviour | Breed | Died | Survived | Wilcoxon P | Log-Rank P |
|---|---|---|---|---|---|
| Time to contact | Finn | 15 ± 9.12 | 7 ± 4.48 | ns | ns |
| (minutes) | Texel | na | 2 ± 1.07 | not estimable | not estimable |
| Time to stand | Finn | 5.2 ± 0.49 | 17.5 ± 5.56 | * | * |
| (minutes) | Texel | na | 16.5 ± 3.36 | not estimable | not estimable |
| Time to locate udder | Finn | 13 ± 4.96 | 25 ± 3.00 | * | * |
| (minutes) | Texel | na | 14.9 ± 2.78 | not estimable | not estimable |

ns=not significant at P<0.05; * P<0.05.

# 6.9 Appendix: Single Texel Dams and their Lambs: Natural versus Assisted Birth.

This section looks specifically at Texel ewes with a single lamb and compares the production and behaviour of ewes that had difficulty lambing and were assisted by the shepherd to those ewes that had a natural birth. A high proportion (50%) of Texel ewes having a single lamb required shepherd assistance to lamb.

## 6.9.1 Ewe Production Traits

Ewes that were assisted at lambing time were significantly lighter at mating and lost less weight from mating to pregnancy scanning (Table 6.9.1). Assisted ewes lambed 11 days later (Table 6.9.1). Ewe weight change between mating and pregnancy scanning had a significant effect on day of parturition in Texel single bearing ewes (P<0.05).

*Table 6.9.1 Ewe liveweight and liveweight change from mating through to lambing (least squares mean ± standard error).*

| | Natural (n=11) | Assisted (n=10) | P |
|---|---|---|---|
| Lambing day | 239 ± 1.62 | 250 ± 2.38 | ** |
| Ewe mating weight (kg) | 53 ± 0.67 | 49 ± 1.41 | * |
| Pregnancy scanning weight (kg) | 47 ± 1.04 | 45 ± 1.12 | ns |
| Prelambing weight (kg) | 48 ± 1.57 | 45 ± 1.21 | ns |
| Ewe weight change between mating and pregnancy scanning (kg) | -5.7 ± 0.88 | -3.5 ± 0.89 | ns |
| Ewe weight change between pregnancy scanning and lambing (kg) | 0.6 ± 0.98 | -0.57 ± 0.58 | ns |
| Ewe weight change between mating and lambing (kg) | -5.1 ± 1.24 | -4.4 ± 1.32 | ns |

ns=not significant at P<0.05; * P<0.05; ** P<0.01; *** P<0.001; **** P<0.0001.

## 6.9.2 Lamb Production Traits

Lamb birth weight was a significant factor determining whether a ewe required the shepherd's assistance with birth (Table 6.9.2). Ewe weight at lambing had a significant effect on lamb birth weight (P<0.0001). The survival rate to weaning of lambs born to assisted ewes was less (P<0.10) (Table 3.2). The following factors had significant effects on lamb survival to weaning for naturally born and assisted lambs: paddock (P<0.01), sire (P<0.05), birth weight (P<0.01) and change in ewe weight between mating and pregnancy scanning (P<0.05).

*Table 6.9.2 Performance of lambs born naturally and to assisted ewes (least squares mean ± standard error).*

| | Natural (n=11) | Assisted (n=10) | P |
|---|---|---|---|
| Birth weight (kg) | 4.3 ± 0.09 | 5.4 ± 0.18 | **** |
| Survival to weaning | 86% ± 1.2 | 58% ± 0.8 | ns |
| Weaning weight (kg) | 30 ± 0.23 | 28.7 ± 3.13 | ns |
| Growth rate to weaning (g/day) | 188 ± 2.31 | 165 ± 24.29 | ns |

ns=not significant at P<0.05; * P<0.05; ** P<0.01; *** P<0.001; **** P<0.0001.

## 6.9.3 Lamb and Ewe Behaviour

Fewer assisted lambs located their dam's udder in the 30-minute recording period and none of the assisted lambs sucked from their dam (Table 6.9.3).

*Table 6.9.3 Proportion of ewes and lambs that did the following behaviour within 30 minutes from birth.*

| | Natural Birth (n=11) | Assisted Birth (n=10) | P |
|---|---|---|---|
| Did make ewe-lamb contact | 90% | 64% | ns |
| Lamb did stand | 60% | 45% | ns |
| Lamb did locate udder | 40% | 9% | ns |
| Lamb did suck | 10% | 0% | ns |

ns=not significant at P<0.05; * P<0.05; ** P<0.01; *** P<0.001; **** P<0.0001.

Assisted ewes took significantly longer to make contact with their lamb following birth (P<0.10) (Table 6.9.4). The following effects were significant for ewe-lamb contact time: paddock, weight change from mating to pregnancy scanning and pregnancy scanning to lambing (P<0.05).

Lambs born to assisted ewes took significantly longer to stand following birth (Table 6.9.4). The following effects were significant for time to stand: birth weight, time of birth, change in ewe live weight between mating and lambing and pregnancy scanning and lambing (P<0.05). The mean time to suck for lambs born to assisted ewes was not estimable due to the lack of observations.

*Table 6.9.4 Time taken for the ewe to make lamb contact, the lamb to stand, locate and suck from its ewe's udder (least squares mean ± standard error).*

| | Natural Birth | Assisted Birth | P |
|---|---|---|---|
| Time to dam-lamb contact (mins) | 1.6 ± 0.71 | 8.8 ± 3.54 | ns |
| Time for lamb to stand (mins) | 4.05 ± 1.36 | 30.6 ± 3.26 | ** |
| Time for lamb to locate udder (mins) | 14.9 ± 2.78 | 21.8 ± 5.57 | ns |
| Time for lamb suck (mins) | 26 | nc | |

ns=not significant at P<0.05; * P<0.05; ** P<0.01; *** P<0.001; **** P<0.0001.

Lambs born to assisted ewes bleated a greater number of times in the 30-minute observation period than lambs born to ewes that did not have difficulty lambing (Table 6.9.5). Assisted ewes did not high bleat, did not prevent sucking, withdraw or butt their lamb.

*Table 6.9.5 Ewe and lamb bleating frequency (least squares mean ± standard error).*

| | Natural Birth | Assisted Birth | P |
|---|---|---|---|
| Lamb bleats | 40.5 ± 10.46 | 95 ± 18.89 | * |
| High ewe bleats | 2 | na | |
| Did high bleat | 10% | 0% | ns |
| Low ewe bleats | 82 ± 33.24 | 54 ± 33.36 | ns |

ns=not significant at P<0.05; * P<0.05; ** P<0.01; *** P<0.001; **** P<0.0001.

Assisted ewes sniffed and groomed their lamb significantly less (Table 6.9.6). Lamb birth weight and the weight of the ewe at pregnancy scanning were significant effects on the amount of lamb sniffing by the ewe (P<0.05). Significant effects on time spent grooming were: paddock, heat loss, lamb birth weight, ewe weight at pregnancy scanning and ewe weight change between mating and lambing (all P<0.0001). Lamb bleating frequency also had a significant effect on the time a ewe spent grooming her lamb (P=0.05). A greater proportion of assisted ewes abandoned their lamb after birth (Table 6.9.6).

Maternal behaviour score of assisted ewes was significantly less as these ewes were separated from their lambs by 6m at the end of the 30-minute recording period (Table 6.9.6). Time of birth was a significant effect on MBS for assisted and natural births (P<0.01). The separation distance was significantly affected by the number of high (P<0.05) and low ewe bleats (P<0.01). Lamb bleating frequency was significantly affected by ewe high and low bleating frequencies (both P<0.05). However, lamb bleating frequency was not a significant factor of ewe high and low bleats (P>0.05). Lamb birth weight (P<0.05) and heat loss (P<0.05) were significant effects on the number of times a ewe facilitated its newborn lamb to suck.

*Table 6.9.6 Ewe behaviour after parturition (least squares mean ± standard error).*

| | Natural Birth | Assisted Birth | P |
|---|---|---|---|
| Sniffing (tally) | 8 ± 3.28 | 0.4 ± 0.17 | * |
| Time grooming (mins) | 17.2 ± 3.99 | 6.6 ± 0.3 | * |
| Facilitates suckling | 2 ± 0.86 | 0.3 ± 0.75 | ns |
| Prevents Suckling | 4 ± 1.59 | 0.0 ± 1.67 | ns |
| Withdrawing | 3 ± 0.99 | 0 ± 1.04 | ns |
| Did withdraw | 50% | 0% | * |
| Butting | 0.2 ± 0.15 | 0 ± 0.15 | ns |
| Did butt | 10% | 0% | ns |
| Abandonment / Rejection | 0% | 40% | ns |
| MBS | 4.7 ± 0.16 | 2.7 ± 0.59 | ** |
| Distance at end of rec. period (metres) | 0.3 ± 0.13 | 6.2 ± 4.11 | ns |

ns=not significant at $P<0.05$; * $P<0.05$; ** $P<0.01$; *** $P<0.001$; **** $P<0.0001$.

# CHAPTER 7

# The effect of Finnish Landrace and Texel ewe and lamb behaviour after tagging on lamb survival to weaning

*Photograph taken by Luc Doornhegge*

Related publications:

Everett-Hincks *et al*. (2004). The effect of Finn and Texel ewe and lamb behaviour after tagging on lamb survival to weaning. *Submitted to the New Zealand Veterinary Journal.*

## 7.1 Summary

The study was carried out on a commercial New Zealand sheep farm with performance recorded straightbred Finnish Landrace and Texel primiparous ewes. The objective of the study was to determine the strength of ewe-lamb attachment at tagging by investigating the behaviour of Finn and Texel ewes and their lambs and relate these behaviours to lamb survival to weaning.

Lamb and ewe behaviour was observed for ten minutes after the lambs were ear tagged (tagging). Finn ewes had lower MBS (undesirable) and took longer to contact their single and twin lambs than Texel ewes (P<0.01). There were no breed differences for time of lamb to stand and suck after tagging. Finn twin lambs took longer to follow their dam (P<0.01) and this may be a result of delayed ewe contact. MBS had a significant effect on ewe-lamb contact time, time for lamb to stand, suck and follow its moving dam (P<0.01). The higher the ewes MBS (favourable) the quicker the time to lamb contact, the quicker the lamb stood, sucked and followed its moving dam.

Texel ewes with twins had higher low bleating frequencies, compared with Texel ewes with a single lamb (P<0.01). MBS had a significant and positive effect on low bleating frequency ($\beta$=19.3 ± 3.51, P<0.0001). Ewes with lower MBS at tagging high bleated significantly more ($\beta$=-4.93 ± 1.08, P<0.0001) and ewes high bleated significantly more if their lamb took longer to stand ($\beta$=5.25 ± 0.65, P<0.0001).

This study shows that lamb behaviour at tagging better explained the variation in lamb survival than the ewe behaviours analysed. Lamb survival improved 3-fold for lambs that suck from their dam (P<0.01) and improved nearly 5-fold for lambs that stand within ten minutes after tagging (P<0.05). This study has also shown that an increase in MBS translates to an improvement weight of lamb weaned ($\beta$=3.5 ± 1.31, P<0.01).

In summary, maternal behaviour influences lamb behaviour and provides evidence that maternal behaviour at tagging, in particular MBS, is important to lamb survival.

## 7.2 Introduction

The behaviour of the ewe before, during and after parturition has a major influence on lamb survival (Nowak *et al.*, 2000) where failure of the lamb and ewe to interact properly can result in lamb deaths and a reduction in returns to the farmer (O'Connor and Lawrence, 1992a). The development of a strong maternal bond is an important prerequisite for lamb survival and it is influenced strongly by continuous association between the ewe and her lamb in the time after birth (Murphy *et al.*, 1994a).

Separation and desertion are likely when the ewe is disturbed (Smith, 1965) as when lambs are 'tagged'. Permanent lamb identification, referred to as 'tagging', currently involves a shepherd catching the lambs in the paddock and temporarily separating them from their dam. Lamb desertion by the ewe may result from the conflict between the normal flocking behaviour of sheep and the isolation associated with maternal behaviour (Kilgour and Szantar-Coddington, 1995). Ewe-lamb separation causes emotional stress and the temporary separation of a lamb from its dam and its littermates is detrimental to its survival (Nowak and Lindsay, 1992; Alexander *et al.*, 1983b; Stevens *et al.*, 1982) and later performance (Napolitano *et al.*, 1995). Orgeur *et al.* (1998) reported that when ewes and lambs temporarily separated from each other they express their distress by an increase in bleating and locomotor activity.

Nowak (1996) and Lindsay *et al.* (1990) suggested that vocal communication between the ewe and the lamb is central to adequate bond formation and has demonstrated that lamb bleating behaviour is involved in the attachment process. Pollard's New Zealand study showed that when lambs were between 6 and 12 hours old, ewes rearing triplets bleated more when their litters were intact and less when one of their lambs was removed compared with ewes with a single lamb (Pollard, 1992). Pollard (1992) found that a 6-12 hour old lamb, which was separated from its dam, was more likely to approach a ewe that was bleating than a silent ewe and concluded that ewe bleats help in long distance recognition of the dam.

Maternal Behaviour Score observed at tagging has been shown to affect lamb and litter survival across a number of traditional and highly fecund ewe breeds (O'Connor *et al.*, 1985; Chapter 3 and Chapter 4). MBS is a good indicator not only for lamb growth but also for the strength of the pre-weaning ewe-lamb relationship (O'Connor, 1996; Chapter 4). Further studies on MBS by Parker and Nicol (1993) showed that lambs of MBS 4 and 5 ewes located their dam's udder in 30% less time than lambs of MBS 3 ewes.

Many believe that maternal behaviours influence lamb behaviour providing evidence that maternal behaviour at parturition is critical to lamb survival (O'Connor *et al*., 1992b; Astroshi and Osterberg, 1979, Dwyer and Lawrence, 1999a). Arnold and Morgan (1975) reported that poor maternal behaviour was the direct cause of 16% of lamb deaths. Poindron *et al*. (1980b) emphasised the importance of lamb behaviour and reported that the behaviour of the neonatal lamb influences the maternal responsiveness of the ewe. Shillito-Walser (1978) also appreciated the importance of effective lamb behaviour concluding that the formation of the maternal-offspring bond in sheep is the result of a rapid learning process influenced by the behaviour of both the ewe and the lamb.

In 2001 a study investigated straightbred primiparous Finnish Landrace and Texel ewes and their lambs under commercial conditions to identify any performance and behaviour differences that could be utilised to improve lamb-rearing success across New Zealand flocks. Anecdotal evidence suggested that there were some phenotypic differences in the behaviour and performance of Finns and Texels (see Chapter 5). The effect of ewe and lamb post parturient behaviour on lamb survival to weaning was described in Chapter 6. The study involved a small sample of Finns and Texels for one parity and large variations were observed within and across the two breeds for the behaviours studied. Breed differences in post parturient behaviour were observed. Texel lambs bleated more than Finn lambs on all occasions. Finn lambs that were less vocal after birth were less likely to survive to weaning. Lamb survival to weaning was also compromised by Finn ewes that showed greater flocking behaviour as indicated by low MBS. Texel ewe behaviours such as time to contact their twin lamb were significant for encouraging survival to weaning.

The aim of this study was to determine the strength of ewe-lamb attachment at tagging by investigating the behaviour of Finn and Texel ewes and their lambs and relate these behaviours to lamb survival to weaning. A relationship was also sought between post-parturient behaviours, identified in Chapter 6 and tagging behaviours identified in this chapter.

# 7.3 Materials and Methods

## 7.3.1 Animals

Animal management, environment and measurement methodology are described in Chapter 5. Texel and Finnish Landrace 2 year old ewes were monitored from mating through to lamb weaning in 2001. This study excludes triplet lambs, ewes with triplet litters and ewes and lambs that were assisted at parturition (Table 7.1).

*Table 7.1 Number of animals included in analyses.*

| | Finn | | | Texel | | |
|---|---|---|---|---|---|---|
| | All | Litter size 1 | Litter size 2 | All | Litter size 1 | Litter size 2 |
| Number of Ewes | 64 | 24 | 40 | 56 | 38 | 18 |
| No. of lambs reared to Tagging | 99 | 24 | 75 | 72 | 38 | 34 |
| No. of lambs reared to Weaning | 68 | 16 | 52 | 55 | 28 | 27 |
| No of lambs that died | 31 | 8 | 23 | 17 | 10 | 7 |

Two shepherds monitored the ewes closely on foot between the hours of 7am and 6pm daily over lambing and for two weeks prior to lambing to allow the ewes to become habituated to human presence. Ewes had been previously ear-tagged so that they could be individually identified from a distance and binoculars were used if necessary.

Mean lambing date for the group of animals in this study was 1$^{st}$ September and 5$^{th}$ September 2001, for Finns and Texels respectively. Birth time was recorded for ewes. The majority of lambs from both breeds were tagged around midday and 5-8 hours from time of birth (Table 7.2).

## 7.3.2 Tagging

Tagging involved the following procedure:

- A brass ear tag was fitted
- The lamb's tail was docked with a rubber ring
- The lamb's inner leg was scratched with a live scabby mouth vaccine

The following information was collected at tagging:

- Lamb (birth) weight
- Lamb sex
- Dam identity
- Tagging date and time

Lambs were tagged where they were found in the paddock. They were left where they were found. If lambs were separated prior to tagging, the litter was brought together possibly enhancing the lamb's chance of survival.

Following tagging, the litter were placed together on the ground, tagging completion time was recorded and the two shepherds moved to a distance of 10-20m where they recorded lamb and ewe behaviours for the following ten minutes on prepared recording sheets.

Lambing day, tagging day and age at tagging differed between breeds (Table 7.2). When tagged, Texel lambs were on average 1½ hours younger than Finn lambs. Texel ewes lambed on average 4 days later than Finn ewes. Although the rams were joined with the two flocks at the same time (Chapter 5). However ewe mating dates differed between the two breeds and the majority of Finns were mated soon after ram joining while Texels were mated later (Chapter 5).

*Table 7.2 Tagging dates and times according to breed (least squares mean ± standard error).*

| | Finn | Texel | P |
|---|---|---|---|
| Mean lambing date | (1st Sept) 243 ± 0.85 | (5th Sept) 247 ± 0.89 | ** |
| Mean tagging date | (1st Sept) 243 ± 0.86 | (5th Sept) 247 ± 0.91 | ** |
| Mean tagging time of day | 11 ± 0.36 | 12 ± 0.32 | ns |
| Mean tagging time from birth (hours) | 7.7 ± 0.68 | 5.8 ± 0.59 | * |

ns = not significant; * P<0.05; ** P<0.01; *** P<0.001; **** P<0.0001.

## 7.3.3 Behaviour

The maternal behaviour score (MBS) of each ewe was determined based on its response to the shepherd tagging its lambs (Table 7.3) (score modified by O'Connor, 1996). The modified score was necessary for the animals used in this study to record the range of behaviour observed.

*Table 7.3 Description of the maternal behaviour scoring system at tagging.*

| Maternal behaviour score description | MBS |
|---|---|
| Dam flees at the approach of the shepherd, shows no interest in the lambs and does not return within the 10 minute observation period. | 1 |
| Dam retreats further than 10 metres but comes back to her lambs as the shepherd leaves them | 2 |
| Dam retreats to such a distance that tag identification is difficult (5-10 metres) | 3 |
| Dam retreats but stays within 5 metres | 4 |
| Dam stays close to the shepherd during handling of her lambs | 5 |
| Dam makes contact with her lambs while they are being handled by the shepherd | 6 |

The ewe behaviours and lamb behaviours that were recorded are shown in Table 7.4. Any animal that failed to perform a specific behaviour in the ten-minute observation period had '0' recorded for that behaviour.

*Table 7.4 Definitions of ewe and lamb behaviours recorded after tagging.*

| Behaviour | Description |
|---|---|
| 1. Ewe behaviours | |
| Lamb contact | Time to make physical contact with lamb (nose the lamb). |
| High-pitched ewe bleats | Made with the mouth open by ewes when they are separated from their lambs. |
| Low-pitched ewe bleats | Made with the mouth closed and emitted when the ewe is in close proximity to the lamb. Sometimes referred to as 'rumble' calls. |
| 2. Lamb behaviours | |
| Stands | Lamb supports itself on all four feet for at least five seconds |
| Successful suck | Lamb standing and has teat in mouth, appears to be sucking for at least 5 seconds. |
| Follows moving ewe | Ewe moves away and lamb follows. |
| Bleats | The number of bleats was recorded for each lamb. |

## 7.3.4 Lamb Performance

Lamb survival in this study was recorded from parturition to weaning. Lambs that survived to weaning were given a score of '1' and lambs that died were given a score of '0'.

Lamb birth weight, weaning weight, growth rate and weight of lamb weaned were recorded (Chapter 5).

## 7.3.5 Statistical Analyses

Data were edited to remove missing records and any data recording errors. Table 7.1 showed the number of animals used in the final dataset.

Differences between breeds within litter size for continuous behaviour traits, such as bleating frequencies and lamb performance traits, such as weaning weight, growth rate and weight of lamb weaned per ewe were tested using PROC MIXED, where data were permitted to exhibit correlation and non-constant variability and eliminated the need for error term construction. PROC MIXED uses restricted/residual maximum likelihood (REML) methods to estimate the random effect (SAS, 2002).

To help decide the pathways involved in the differences in bleating behaviour, MBS and lamb performance, analyses of covariance were performed and were retained in the model if statistically significant at $P<0.05$.

The following linear model was used:

$$Y_{ijk} = \mu + A_i + L_j + A_i{*}L_j + \beta_1 X_{ijk} + e_{ijk}$$

where $Y_{ijk}$ is the record of the $k^{th}$ animal of the $i^{th}$ breed and the $j^{th}$ litter size at birth,

$\mu$ is the general mean,

$A_i$ is the fixed effect of the $i^{th}$ breed (*i*=Finn or Texel),

$L_j$ is the fixed effect of the $j^{th}$ litter size at birth (*j*= single or twin),

$AL_{ij}$ = fixed interaction effect of breed *i* and litter size at birth *j*,

$X_{ijk}$ is the performance or behaviour trait measured (e.g. lamb birth weight, time to stand, pasture cover) in the $i^{th}$ breed of the $j^{th}$ litter size,

$\beta_1$ is the regression of the behaviour or performance trait of interest (e.g. MBS, weight of lamb weaned) on the behaviour or performance trait (e.g. time to stand, lamb birth weight), and

$e_{ijk}$ is the random residual effect unique to $Y_{ijk}$,

The covariance structure of the data was modelled using the REPEATED option in PROC MIXED. Results are given as least square means and the standard error of the difference between means for the contrasts of Finns and Texels, single and twin litters, and the interaction between the main factors.

The LIFETEST procedure (SAS, 2002) was used to compute and plot the distribution estimate of ewe and lamb time related behaviours after tagging, such as ewe-lamb contact time, time for lamb to stand, suck and follow the moving ewe. These behaviour observations are skewed and right-censored due to the termination of the experiment (i.e. ten minutes after tagging). This analysis procedure correctly uses the censored observations as well as the non-censored. The LIFETEST procedure generates a survival distribution function (SDF) and is used in this case to describe the behaviour times. The SDF evaluated at time ($t$) (i.e. 10 minutes) is the probability that a lamb of a particular breed and litter size will have a 'behaviour' time exceeding $t$, that is:

$$S(t) = Pr(T>t),$$

where S($t$) denotes the survival distribution function and T is the behaviour time of a randomly selected lamb. The cumulative distributive functions for each of the behaviour traits are graphically plotted and are defined as 1-S($t$), that is the probability that a behaviour time does not exceed time ($t$) (i.e. 10 minutes). To determine whether the curves plotted are homogenous across breeds and or litter sizes (and order of birth) ($P>0.05$), PROC LIFETEST provides two rank tests (log-rank and Wilcoxon). The Wilcoxon test places more weight on early times and the log-rank test places more weight on larger times. The association between covariates and the behaviour time variable were investigated using the Wilcoxon Test and reported if significant at $P<0.05$. The covariate tests are pooled across treatments and it is not possible to calculate the directional effect the covariate is having on the dependent variable.

The LOGISTIC procedure (SAS, 2002) was used to obtain maximum likelihood estimates of the regression coefficients. Ninety five percent confidence intervals and odds ratios were calculated by specifying the appropriate options in the model statement. The odds ratio is a statistical measure of how likely or unlikely it is for animals exposed to a risk factor to show the outcome of interest. An odds ratio of one indicates no association between the risk factor and the probability of the outcome being modelled. For example, in the context of the present study, lamb survival to weaning (0=died, 1=survived) is the outcome of interest and behaviour of the lamb and dam after tagging (e.g. 0=did not stand, 1= did stand) is the risk factor thought to be associated with lamb survival to weaning. An odds ratio of 2 indicates that lambs that do stand after tagging are two times more likely to survive to weaning than those that do not.

# 7.4 Results

## 7.4.1 Tagging Behaviour

The effect of litter size and the interaction between litter size and breed were not significant for MBS (P>0.05). Ewe breed had a significant effect on MBS (P<0.0001) (Table 7.5). Finn ewes had significantly lower MBS recorded at tagging and it did not increase with increasing litter size, Ewe high bleating frequency significantly affected MBS (β=-0.02±0.004, P<0.0001).

*Table 7.5 The effect of breed on ewe MBS after tagging (least squares mean± standard error).*

| Litter size | Finn | Texel | P (breed) |
|---|---|---|---|
| All | 2.8 ± 0.097 | 3.7 ± 0.115 | **** |
| | | | |
| Single | 2.7 ± 0.165 | 3.5 ± 0.157 | ** |
| Twin | 2.8 ± 0.100 | 3.9 ± 0. 166 | **** |
| P (Litter size) | ns | ns | |

ns=not significant at P<0.05; * P<0.05; ** P<0.01; *** P<0.001; **** P<0.0001.

Post tagging behaviour times were analysed using the Lifetest procedure and the comparison of cumulative distributions were made within litter size across breed and are reported in Table 7.6 and Figures 7.1 to 7.4.

*Table 7.6 The effect of breed on ewe and lamb behaviour after birth (Wilcoxon mean ± standard error).*

| Behaviour | Litter size | Finn | Texel | Wilcoxon P | Log-Rank P |
|---|---|---|---|---|---|
| Time to contact (minutes) Figure 7.1. | Single | 1.10 ± 0.259 | 0.49 ± 0.099 | ** | ** |
| | Twin | 2.16 ± 0.289 | 0.71 ± 0.154 | **** | *** |
| Time to stand (minutes) Figure 7.2. | Single | 0.86 ± 0.266 | 0.91 ± 0.323 | ns | ns |
| | Twin | 0.81 ± 0.178 | 0.77 ± 0.252 | ns | ns |
| Time to suck (minutes) Figure 7.3. | Single | 3.08 ± 0.874 | 3.83 ± 0.633 | ns | ns |
| | Twin | 3.86 ± 0.466 | 3.44 ± 0.596 | ns | ns |
| Time to follow (minutes) Figure 7.4. | Single | 2.06 ± 0.478 | 2.42 ± 0.449 | ns | ns |
| | Twin | 2.60 ± 0.298 | 1.22 ± 0.294 | ** | ** |

ns=not significant at P<0.05; * P<0.05; ** P<0.01; *** P<0.001; **** P<0.0001.

The time for ewes to contact their single and twin lambs differed significantly between breed, with Finn ewes taking longer to make contact (Table 7.6). Ewe contact time with single lambs was significantly affected by MBS, high bleating frequency (P<0.0001) and lamb sex and sire of lamb (P<0.05). One minute after tagging 84% of single Texel lambs had ewe contact compared to 54% of Finns (Figure 7.1). Nearly 80% of Texel twin lambs had ewe contact one minute after tagging compared to 40% of Finn twin lambs (Figure 7.1). Twin lamb contact was significantly affected by MBS and high bleating frequency (P<0.0001), low ewe bleating (P<0.05) and lamb bleating frequency (P<0.01). Ewe-lamb contact time was quicker if the ewe had higher MBS, high bleated fewer times and low bleated more. Ewe-lamb contact time was also quicker if twin lambs bleated.

Lamb breed did not significantly affect time to stand and time to suck for single and twin lambs (Table 7.6). Within one minute after tagging between 70% and 80% of all lambs had stood (Figure 7.2). Ewe high bleating frequency (P<0.011) and MBS (P<0.10) had a significant effect on time for single and twin lambs to stand. Lamb sex (P<0.05) also affected single lamb time to stand, whereas ewe weight prior to lambing (P<0.05) had a significant effect on time to stand for twin lambs. Lambs were quicker to stand after tagging if their dam had higher MBS and high bleated fewer times.

Twin Finn lambs took longer to follow their moving dam compared to twin Texel lambs (Table 7.6). Nearly 30% of twin Texel lambs followed their moving dam within one minute of tagging, compared to only 2% of Finns, whereas 55% of twin Texel lambs had followed ten minutes after tagging compared to 70% of Finns (Figure 7.4). Ewe MBS and lamb bleating frequency had a significant affect on time to follow (all P<0.01). Lambs were quicker to follow their moving dam if she had higher MBS at tagging. Lambs that bleated more took longer to follow their dam.

Approximately half of all lambs had sucked from their dam ten minutes after tagging (Figure 7.3). Lambs were quicker to suck from their dam with higher MBS.

*Figure 7.1 The effect of breed on the proportion of single and twin lambs to have ewe contact after tagging*

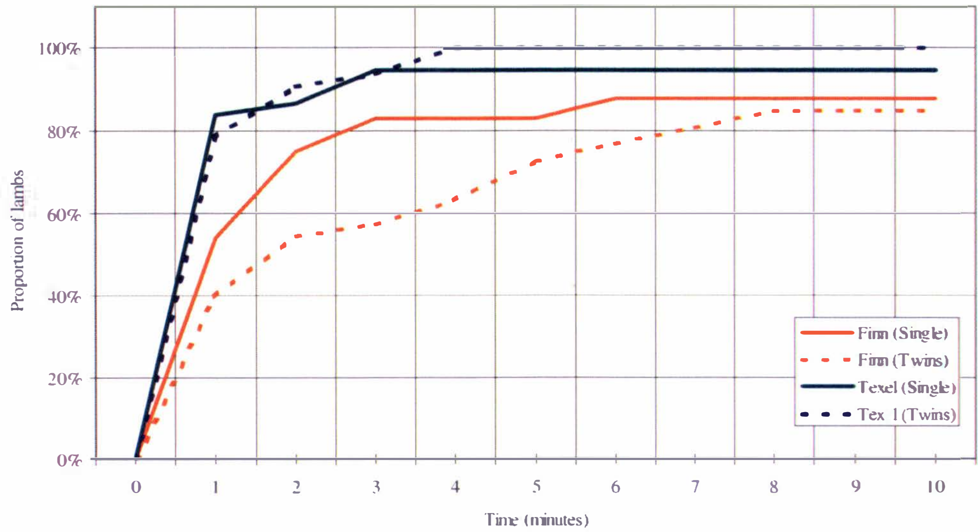



*Figure 7.2 The effect of breed on the proportion of single and twin lambs to stand*

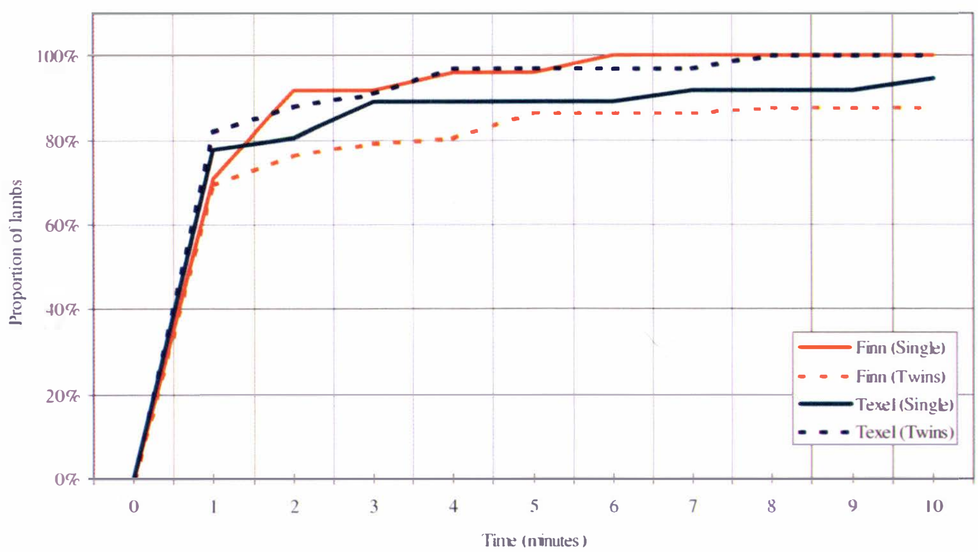



*Figure 7.3 The effect of breed on the proportion of single and twin lambs to suck*

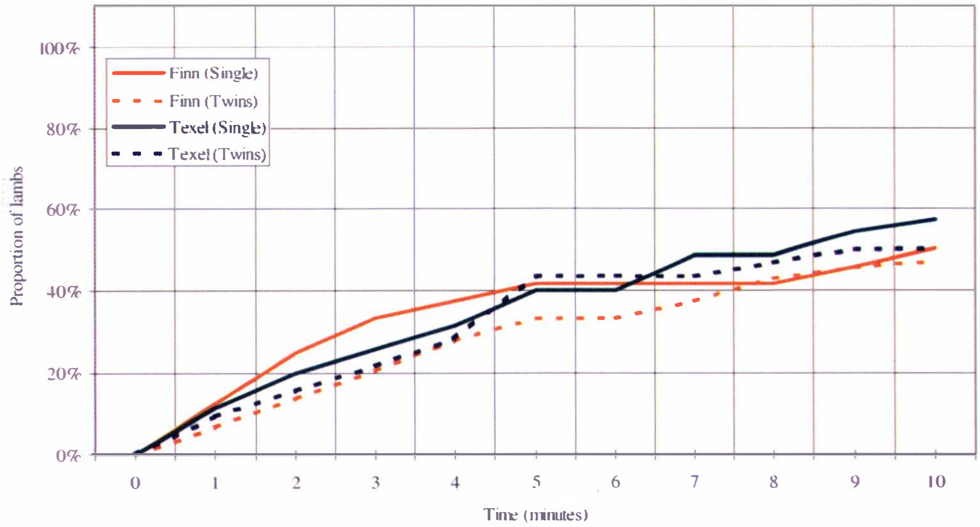
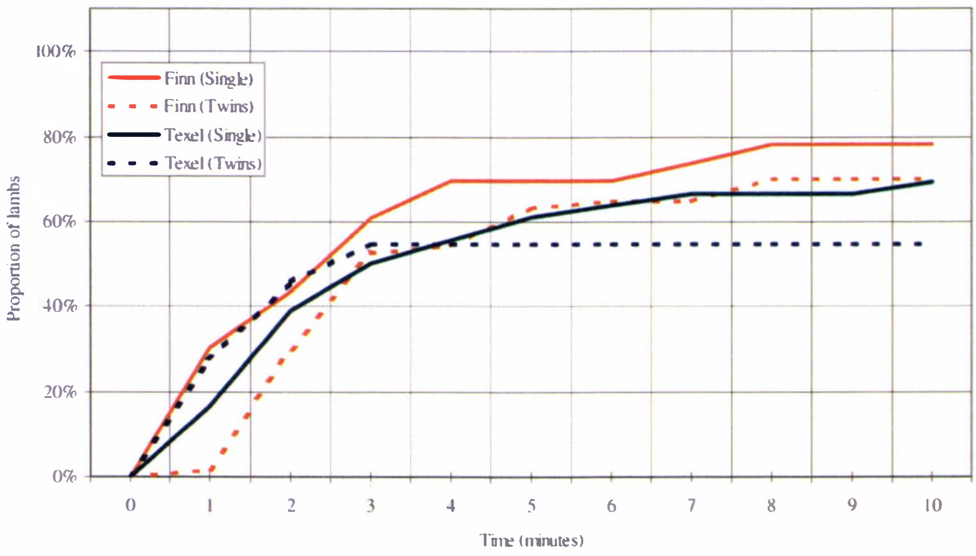


*Figure 7.4 The effect of breed on the proportion of single and twin lambs to follow their moving dam within ten minutes after tagging.*




Lamb breed, litter size at birth and the interaction between breed and litter size were not significant (P>0.05) factors affecting lamb bleating frequency. Finn and Texel lambs had similar bleating frequencies recorded within ten minutes after tagging (Table 7.7). However MBS did have a significant effect on lamb bleating frequency ($\beta$=-5.03±2.14, P<0.05).

*Table 7.7 The effect of breed and litter size on ewe and lamb bleating behaviour after tagging (least squares mean ± standard error).*

| Behaviour | | Litter size | Finn | Texel | P (breed) |
|---|---|---|---|---|---|
| Lamb bleating frequency | | Single | 29 ± 9.04 | 18 ± 3.38 | ns |
| | | Twin | 29 ± 5.52 | 23 ± 4.07 | ns |
| | P (Litter size) | | ns | ns | |
| Ewe low bleating frequency | | Single | 43 ± 8.77 | 23 ± 6.93 | 0.07 |
| | | Twin | 49 ± 5.4 | 47 ± 8.12 | ns |
| | P (Litter size) | | ns | ** | |
| Ewe high bleating frequency | | Single | 11 ± 3.78 | 10 ± 1.64 | ns |
| | | Twin | 17 ± 2.5 | 10 ± 1.82 | * |
| | P (Litter size) | | ns | ns | |

ns=not significant at P<0.05; * P<0.05; ** P<0.01; *** P<0.001; **** P<0.0001.

Breed of ewe and the interaction between breed and litter size were non-significant fixed effects in the model (P>0.05) for ewe low bleating frequency. Texel ewes with twin lambs low bleated significantly more after tagging than Texel ewes with a single lamb (Table 7.7). Litter size did have a significant effect on ewe low bleating frequency where ewes with twins bleated significantly more (48 ± 4.44) than ewes with a single lamb (33 ± 5.46) ($P<0.05$). Ewes with higher MBS low bleated significantly more than ewes with lower MBS ($\beta$=19.3 ± 3.51; $P<0.0001$). Ewes with lower live weights at pregnancy scanning ($\beta$=-3.2 ± 1.52; $P<0.05$) and higher live weights at lambing, bleated significantly more ($\beta$=3.14 ± 1.3; $P<0.05$). Day of tagging ($\beta$=1.31±0.44, $P<0.01$) and hours from birth at time of tagging ($\beta$=-1.22±0.58, $P<0.05$) also had significant effects on ewe low bleating frequency.

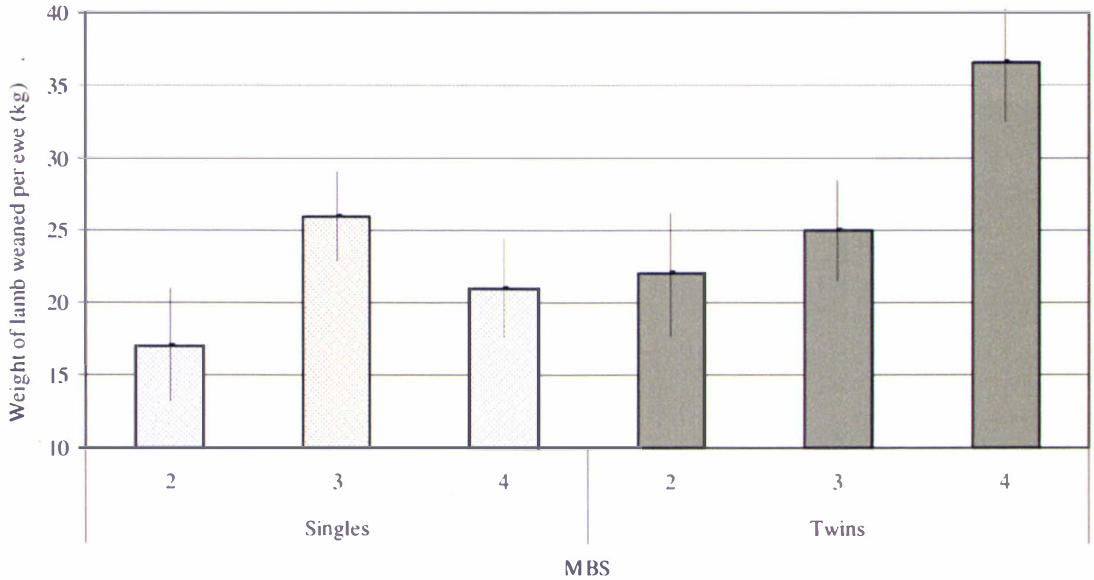
The fixed effects in the model for ewe high bleating frequency were not significant ($P>0.05$), however Finn ewes with twin lambs high bleated significantly more than Texel ewes with twin lambs (Table 7.7). Time for lamb to stand ($\beta$=5.25 ± 0.65, $P<0.0001$) and ewe MBS ($\beta$=-4.93 ± 1.08, $P<0.0001$) had significant effects on ewe high bleating frequency. Ewes high bleated more if their lambs took longer to stand and they had lower MBS at tagging.

### 7.4.2 Post Tagging Behaviour and Lamb Performance

The fixed effects of breed and the interaction between breed and litter size were non-significant effects in the model for weight of lamb weaned ($P>0.05$). Litter size had a significant effect on weight of lamb weaned ($P<0.05$). Ewes with a single lamb at birth weaned 22 ± 1.93kg and ewes with twin litters weaned 30 ± 2.2kg. Weight of lamb weaned was significantly affected by MBS ($\beta$=3.5 ± 1.31, $P<0.01$) and ewe liveweight pre-lamb ($\beta$=-1.2 ± 0.25, $P<0.0001$).

Further analysis identified a significant increase in weight of lamb weaned with an increase in MBS within litter size (Figure 7.5). For this part of the analysis MBS was grouped into three categories. Due to insufficient sub-class numbers, MBS 1 and 2 were grouped into MBS 2 (representing 'poor mothers') and MBS 4, 5 and 6 were grouped into MBS 4 ('excellent mothers'). MBS 3 stayed as it was ('good mothers'). Ewes with twin litters weaned significantly greater weight of lamb if they had an MBS of 4 or greater at tagging compared to ewes with and MBS of 3 and lower ($P<0.05$). The relationship between MBS and weight of lamb weaned for ewes with a single lamb was not significant ($P>0.05$), however ewes with an MBS less than 3 weaned less lamb than ewes with an MBS of 3 ($P=0.07$).

*Figure 7.5. The effect of MBS within litter size on weight of lamb weaned per ewe (least squares mean ± standard error).*




Lamb performance was generally not affected by the ewe and lamb behaviours recorded after tagging. Lamb weaning weight and growth rates were not affected by behaviours recorded in this study and were primarily affected by lamb birth weight and ewe liveweight change in late pregnancy (refer to Chapter 5).

Lamb birth weight was significantly higher for Texels (4.3 ± 0.11kg) than for Finns (3.5 ± 0.08 kg)($P<0.0001$) and was significantly affected by ewe live weights pre-mating ($\beta=-0.04 \pm 0.015$) and pre-lamb ($\beta=0.10 \pm 0.015$, $P<0.0001$), day of birth ($\beta=0.02 \pm 0.007$, $P<0.01$) and significantly affected time for lamb to stand ($\beta=-0.08 \pm 0.034$, $P<0.05$).

## 7.4.3 Post Tagging Behaviour and Lamb Survival

The results of the multiple logistic regression for Finn and Texel lambs are summarised in Table 7.8 and describe how the odds of survival to weaning changes as behaviour changes after tagging from '0' (e.g. did not stand) to '1'(e.g. did stand) and as litter size and breed changes. The chance of survival to weaning was higher for Texel lambs but not significantly different from Finns (i.e. OR=0.76 for Finns; P=ns). Twin lambs had 40% improved survival odds to weaning than single lambs, however twins and singles were not significantly different (Table 7.8).

Lambs that did not suck after tagging had 30% odds of survival to weaning compared to those that did (P<0.05). The odds for lamb survival was lowest for lambs that did not stand (OR=0.22), that is the chance for a lamb to survive to weaning was only 22% for those that did not stand after tagging compared to those that did (P=0.11) (Table 7.8).

*Table 7.8 Regression coefficient estimates, odds ratios and 95% confidence intervals for the odds ratios and probability levels from logistic regression analysis of all lambs and their chance of survival to weaning.*

| Group | Variable | Regression Coefficient | Odds Ratio (OR) | 95% (CI) Confidence Interval | P |
|---|---|---|---|---|---|
| Breed | Finn | -0.14 ± 0.317 | 0.76 | 0.22 – 2.65 | ns |
| | Texel | 0 | 1 | | |
| Litter size | One | -0.26 ± 0.252 | 0.60 | 0.22 – 1.61 | ns |
| | Two | 0 | 1 | | |
| Dam Behaviour | MBS 2 | -0.12 ± 0.40 | 1.08 | 0.26 – 4.54 | ns |
| | MBS 3 | 0.31 ± 0.35 | 1.66 | 0.46 – 5.98 | ns |
| | MBS 4 | 0 | 1 | | |
| | Made contact | 0 | 1 | | |
| | Did not make | -0.06 ± 0.413 | 0.89 | 0.18 – 4.49 | ns |
| Lamb Behaviour | Did stand | 0 | 1 | | |
| | Did not stand | -0.76 ± 0.483 | 0.22 | 0.03 – 1.44 | 0.11 |
| | Did follow Dam | 0 | 1 | | |
| | Did not follow | -0.28 ± 0.276 | 0.57 | 0.19 – 1.69 | ns |
| | Did suck Dam | 0 | 1 | | |
| | Did not suck | -0.60 ± 0.243 | 0.30 | 0.12 – 0.78 | * |

ns = not significant; * P<0.05; ** P<0.01; *** P<0.001; **** P<0.0001.

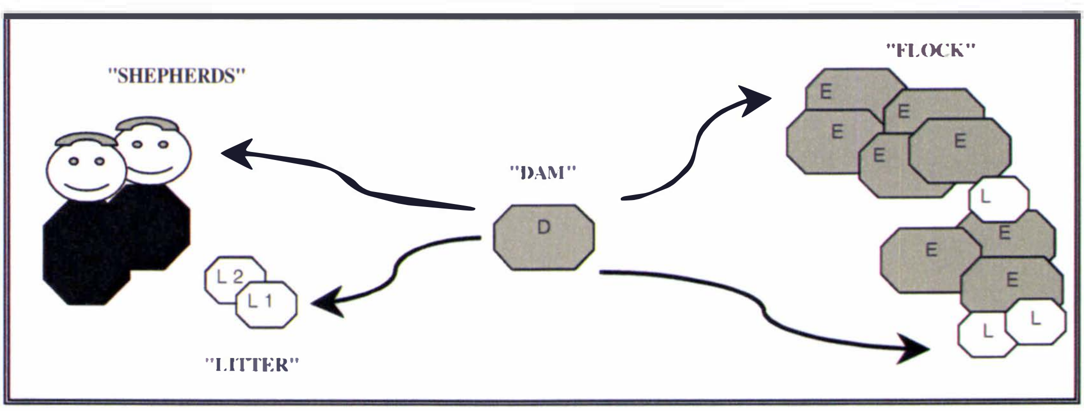
Further analyses were performed and stepwise logistic regression was used. This procedure only fitted statistically significant variables into the model (P<0.05) and identified lamb sucking and standing behaviour as the behaviour responses most likely to affect lamb survival. A lamb that did not suck from its dam had a 27% chance of survival compared to a lamb that did (OR=0.27; CI=0.11-0.68; P<0.01). A lamb that did not stand had a 17% chance of survival to weaning compared to a lamb that did (OR=0.17; CI=0.03-0.87; P<0.05).

# 7.5 Discussion

In this study lamb ear-tagging was performed when the lambs were between five and eight hours old and was performed earlier than under commercial conditions (lambs 12-24 hours old). According to Murphy *et al.* (1994a) bonding and consequently survival of twins can be considerably improved if the ewe remains together with her lambs for a minimum of 6 hours after birth, therefore lamb survival should not have been affected by tagging the lambs at a younger age.

Ewe maternal behaviour and lamb behaviour at tagging was investigated. Tagging temporarily separates a ewe and her litter. Ewes react differently to the separation and this will be further modified by the involvement of the shepherd. Depending on the strength of the bond formed with her litter, the fear for the shepherd, the visibility of her lambs versus flock lambs, the proximity of the flock and the dam's 'drive' to be with the flock, the dam will stay close to her litter or desert them in favour for the flock (Figure 7.6).

*Figure 7.6. Behaviour conflicts for the dam when her litter is being ear-tagged (where D= Dam, L1 and L2 =Dam's Litter, L= Flock Lamb, E=Flock Ewe).*




In this study MBS varies with breed. MBS gives an indication of a ewe's degree of attachment to her lambs in the first days following parturition when challenged with human presence (Figure 7.6). Finn ewes had lower MBS and took longer to contact their twin lambs.

MBS had a significant effect on ewe-lamb contact time, time for lamb to stand, suck and follow its moving dam. Ewes that were closer to their lamb at tagging, as determined by higher MBS, were quicker to contact their lamb after tagging, their lambs stood sooner, sucked and followed sooner. According to Alexander (1988), mother-young acceptance is more likely if the newborn lamb has the following desirable traits; stands soon after birth, sucks soon after standing, follows their mother closely and moves to the mother if separated. There were no breed differences for time of lamb to stand and suck after tagging. Finn twin lambs took longer to follow their dam and this may be a result of delayed ewe contact. Astroshi and Osterberg (1979) observed that an increase in birth weight shortened the time from birth to standing. This study showed a similar relationship between birth weight and time to stand after tagging.

In this study ewes with lower MBS at tagging high bleated significantly more. This result supports observations by Dwyer *et al.* (1998b). They suggested that high-pitched bleating is affected by ewe breed and may reflect the likelihood of separation of the ewe from the lamb. Our results contradict those of Lindsay *et al.* (1990) who suggested that the best mothers were those that were less active in stressful situations and those that bleated more often. However Lindsay *et al.* (1990) did not specify whether the ewe bleats were high or low pitched. The ewes in this study high bleated significantly more if their lamb took longer to stand, suggesting that ewes bleated more in stressful situations.

Texel ewes with twins low bleated more frequently than Texel ewes with a single lamb. MBS had a significant and positive effect on low bleating frequency. Ewes with younger lambs at tagging also low bleated significantly more. Dwyer *et al.* (1998b) suggested that the low-pitched bleat rate of maternal ewes may be a reflection of her intrinsic physiology and the higher rate in primiparous ewes may reflect her inexperience, immaturity and therefore slower bond formation. Nowak (1996) suggests that vocal communication between the ewe and the lamb is central to adequate bond formation and has demonstrated that lamb bleating behaviour is involved in the attachment process.

Lindsay *et al.* (1990) observed that increased vocal behaviour of lambs was strongly associated with earlier recognition of their mother and better bonding. Lamb bleating behaviour after tagging was similar between breeds and lambs of different litter sizes in this study. However lamb bleating frequency was significantly higher when the ewe had lower MBS at tagging, therefore inferring that the lamb is aware of its separation from its dam and is trying to locate her. Lamb vocalisations are modified by their rearing experience and appear to represent a signal of need (Dwyer *et al.*, 1998b).

### 7.5.1 Relationship between post-parturient and tagging behaviours

Cloete *et al.* (2002) showed that time to stand from birth and time to suck from standing do have a genetic component and that it differs between breeds. Therefore, it is likely that lamb survival to weaning can be improved by incorporating these lamb behaviours in animal breeding programmes. However behaviour observed and recorded after tagging requires less effort and supervision than after parturition and better fits with current farm management practices in performance recorded flocks.

Further analyses were required to investigate whether a relationship exists between the post-parturient behaviours observed in Chapter 6 and the behaviours recorded in this study (Chapter 7). Phenotypic correlations were derived using ASREML (Gilmour *et al.*, 1998) and adjusted for breed and litter size.

*Table 7.9 Phenotypic correlations between post-parturient and post-tagging behaviours observed in this study (phenotypic correlation ± standard error).*

| Post-Parturient behaviour (Chapter 6) | Post-tagging behaviour (Chapter 7) | Pairs n | Phenotypic correlation | P |
|---|---|---|---|---|
| Ewe Behaviours | | | | |
| MBS | MBS | 30 | 0.42 ± 0.156 | * |
| Ewe high pitched bleats | Ewe high pitched bleats | 37 | 0.29 ± 0.177 | ns |
| Ewe low pitched bleats | Ewe low pitched bleats | 36 | 0.60 ± 0.11 | * |
| Time to first contact lamb | Time to contact lamb | 50 | -0.02 ± 0.141 | ns |
| Lamb behaviours | | | | |
| Time to first stand | Time to stand after tagging | 40 | -0.37 ± 0.155 | * |
| Time to first suck | Time to suck | 8 | 0.06 ± 0.368 | ns |
| Time to first locate udder | Time to udder | 16 | 0.10 ± 0.234 | ns |

ns = not significant; * P<0.05; ** P<0.01; *** P<0.001; **** P<0.0001.

The phenotypic correlations show that a relationship does exist between some of the behaviours observed immediately after birth and the behaviours observed after tagging (Table 7.9). MBS was recorded when the shepherd interfered with the dam's litter at spray marking and at tagging. The phenotypic correlation was moderate and significant and therefore a reliable indicator of the ewe's flocking response when temporarily separated from her litter (Table 7.9). However the correlation was not high and suggests that temporary environmental effects are large. The ewes ability to communicate with her litter after tagging was related to the low bleating frequency after birth (Table 7.9).

A lamb that is quick to stand after birth is slower to stand after tagging, as indicated by the negative moderate correlation (Table 7.9). The reason for this negative relationship is unclear, but it may have arisen from the behaviour being observed under different circumstances. That is at tagging the lamb may have viewed the shepherd as a predator and instead of choosing the 'flight' response chose to 'freeze' (Boissy, 1998). Another possible explanation is that the lamb showed a reduced fear response as it already had a previous experience with the shepherd after birth (when the lamb was spray marked) and therefore did not choose the 'flight' response. Observation of the lambs after tagging supports the former explanation. Logistic regression analyses showed that the odds of lamb survival improved if a lamb stood after tagging, therefore it assumed that a lamb that 'freezes' during times of emotional stress is likely to become separated from its dam and separation can lead to death from starvation (Nowak and Lindsay, 1992).

Separation from its dam can be defined as a form of emotional stress (Napolitano *et al.*, 1995). Therefore the lamb's behaviour choice at different stages of its development can affect its chance of survival. Separation in the first few days of life will be detrimental to a lamb that 'freezes' if its dam has a strong flocking response (low MBS) and she is not attracted back to the birth site. However if the lamb chose the 'flight' response it may have had a better chance of being reunited with its dam. Alternatively a lamb that chooses to 'freeze' and its dam has a high MBS, has an improved chance of being reunited with its dam, therefore improving its chance of survival.

This study has shown that an increase in MBS translates to an improvement in weight of lamb weaned. O'Connor *et al.* (1985) also observed an improvement in weight of lamb weaned per ewe mated with increasing MBS. Selection for improved MBS must therefore improve production. However MBS is affected by breed, therefore it is important for farmers to know the effects of MBS in their flock before they start selecting for improved lamb behaviour.

## 7.6 Conclusion

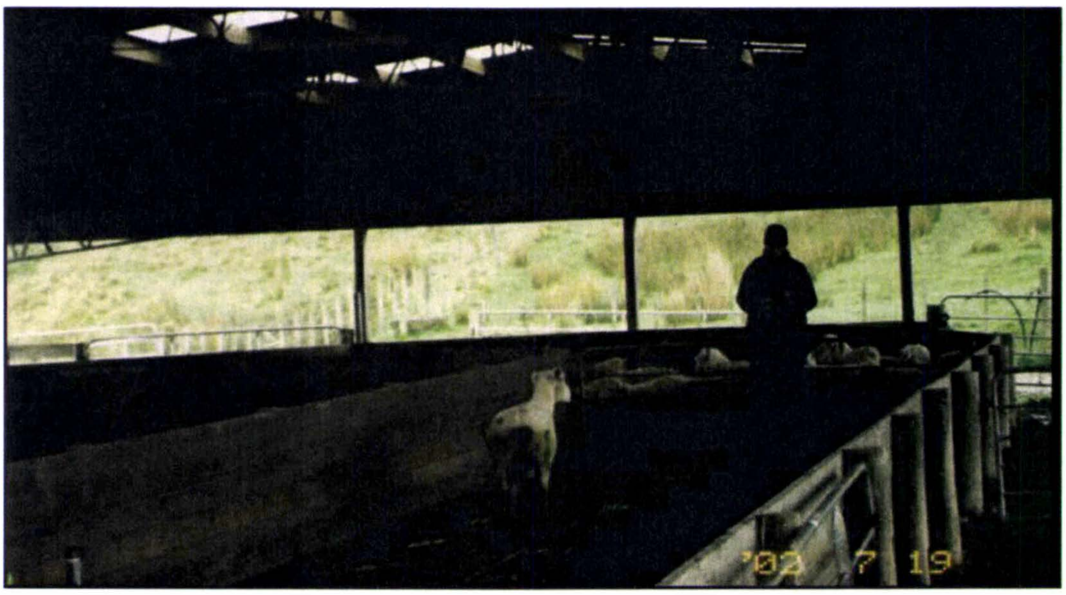
O'Connor and Lawrence (1992a) found that it is lamb behaviour, not maternal behaviour that is the major factor limiting lamb survival. This study showed that lamb behaviour at tagging significantly improved lamb survival odds when compared with the ewe behaviour analysed. In particular, a lamb that stands and sucks has significantly improved chance of survival to weaning; lamb survival was improved 3-fold for lambs that suck from their dam and improved nearly 5-fold for lambs that stand within ten minutes after tagging.

It cannot be discounted that maternal behaviour has an affect on lamb behaviour. O'Connor *et al.* (1985) suggested that maternal effects influence lamb behaviour providing evidence that maternal behaviour at parturition and at tagging, as expressed in the MBS, is critical to lamb survival. More importantly a lambs and dam's response to stress induced by the shepherd at tagging is a good predictor of lamb survival and lamb production.

Further research is needed to determine whether the stress induced at tagging can be replicated at an earlier stage, preferably before the breeding season and whether the ewe's behavioural response at this time is indicative of her behaviour and lambs behaviour at tagging. This is explored further in Chapter 8 and 9 where the Arena Behaviour Test (Kilgour and Szantar-Coddington, 1995) has been used to identify behaviours that predict maternal behaviour and lamb-rearing ability. The relationship between arena behaviour and Maternal Behaviour Score is also investigated.

CHAPTER 8

# An investigation of the relationship between ewe arena behaviour and lamb rearing performance



*Photograph taken by Barbara Gallagher*

## 8.1 Summary

This study investigated genetically divergent lines of Romney sheep with high or low insulin like growth factor (IGF-1), to determine if ewe behaviour in an arena test can be used to predict lamb-rearing ability. There is an inverse relationship between dam IGF-1 concentrations and lamb birth weight (Blair *et al.*, 2002). Lamb birth weight is the dominant factor in lamb survival (Hinch *et al.*, 1983 and Geenty, 1997).

A modified Arena Behaviour Test, similar to that described by Kilgour and Szantar-Coddington (1995) was performed on High IGF-1 (n=88), Low IGF-1 (n=81) and Control ewes (n=65 ewes) in an attempt to identify behaviours that predict lamb-rearing ability. The relationship between arena behaviour and Maternal Behaviour Score was also investigated.

Arena and maternal behaviour tend to differ between selection lines. The Control ewes showed stronger flocking behaviour than the High and Low IGF ewes. The Control ewes were less perturbed by the person in the arena. They had lower mean, minimum and maximum distances from the person in the arena and approached Zone 3 at a faster speed. A greater proportion of Control ewes entered Zone 2 (closest to person and group sheep), spent more time in Zone 2 and were more likely to interact with penned sheep.

The relationship between arena behaviour and maternal behaviour was not strong for all ewes. There was a moderate positive correlation between the time High IGF ewes spent in Zone 5 (farthest from person and group sheep) and MBS ($r$=0.30; P<0.05). This correlation was not significant for the Control and Low IGF sheep. High IGF ewes with a lower flocking tendency in the arena have higher maternal behaviour scores at tagging.

Lamb rearing performance was similar between the three groups. The arena behaviour traits, which showed some promise as indicators of lamb rearing performance to weaning in Romney sheep, were fewer high pitched bleats and a slower approach to the person and penned sheep.

Ewe temperament appears to be under genetic control and is a likely predictor for lamb rearing performance as ewe temperament differs between selection lines. The arena test behaviour or a modified version thereof is worthy of further investigation as a means of measuring lamb-rearing performance.

## 8.2 Introduction

Low birth weights are associated with poorer lamb survival rates to weaning. Lambs weighing less than 3 kg at birth have a very low survival rate (Dalton *et al.*, 1980; Nowak and Lindsay, 1992). Insulin like growth factor –1 (IGF-1) plays an important role in metabolism promoting growth. In genetically divergent lines of Romney sheep there is an inverse relationship between dam IGF-1 concentrations and lamb birth weight (Blair *et al.*, 2002). Birth weights of lambs born to High IGF ewes were 0.7 kg less than lambs born to Low IGF ewes with Control lambs being intermediate. An increase in lamb birth weight would improve survival where dystocia was not anticipated (Blair *et al.*, 2002). Lamb birth weight is a dominant factor influencing the survival of lambs (Hinch *et al.*, 1983).

It is unknown to what extent selection for production characters, such as increased birth weight and growth rate, has resulted in genetically correlated changes in behaviour (Key and MacIver, 1980) and temperament. Poor ewe behaviour is an important cause of lamb death (Nowak, 1996) and desertion leads to death by starvation. Desertion may result from the conflict between the flocking behaviour of sheep and the isolation associated with maternal behaviour (Kilgour and Szantar-Coddington, 1995).

Sheep breeders have selected for traits thought to improve lamb survival, such as maternal behaviour score (MBS) (O'Connor *et al.*, 1985) and arena behaviour (Kilgour and Szantar-Coddington, 1995). Maternal behaviour score (MBS) has been positively associated with lamb weaning weight (O'Connor, 1996; O'Connor *et al.*, 1985; Chapter 4 and Chapter 7). The Arena Behaviour Test has been used in Australia to predict the lamb-rearing ability of Merino ewes (Kilgour, 1998). The Trangie Fertility flock, selected on lamb rearing ability, and the Random flock, unselected, were established in 1959 (Kilgour and Szantar-Coddington, 1995). Of the arena behaviour traits measured by Kilgour and co-workers (1995, 1997) and Kilgour (1998), total distance travelled differed consistently between the Fertility flock and the Random flock, and the Fertility flock travelled only 60% as far as the Random flock (Kilgour, 1998). Number of bleats also differed consistently between flocks and the Fertility ewes and rams bleated less than their Random flock contemporaries at 6 and 12 months of age (Kilgour 1998). They concluded that the arena behaviour test predicts differences in the maternal behaviour of ewes and that it is a possible selection criterion for the genetic improvement of lamb rearing ability (Kilgour, 1998; Kilgour and Szantar-Coddington, 1995). Multiple arena tests were performed at different ages on the same animal and they showed a moderate to high repeatability indicating that the behaviour of the animal in the arena test was consistent over time (Kilgour and Szantar-Coddington, 1995). Murphy *et al.* (1994b) also showed that their modified arena test was highly repeatable when assessed at weaning, hogget age and 2.5 years.

A behaviour recorded at an early stage in the animal's life cycle indicative of maternal behaviour, preferably before its first reproductive experience, would be of great benefit for farmers wanting to select ewes with improved lamb rearing performance. The Arena Behaviour Test previously used by Kilgour and Szantar-Coddington (1995) to predict lamb rearing ability in Merino sheep will be used in this study to determine whether the Romney ewe's behavioural response at this time is indicative of her Maternal Behaviour Score (MBS) at tagging. The Romney ewe is the traditional and most predominant breeding ewe in New Zealand and therefore warrants investigation to determine whether there is sufficient variation in ewe temperament to enable effective selection and subsequently genetic improvement in lamb rearing performance. Selection methods to improve lamb survival resulting from studies on Romney sheep would have the greatest adoption rates and subsequent benefits to the New Zealand sheep Industry.

A number of studies have shown a positive relationship between birth weight and lamb survival (Petersson and Danell, 1985; Dalton *et al.*, 1980; Hinch *et al.*, 1986; Maund *et al.*, 1980). Recent studies by Blair *et al.* (2002) showed an inverse relationship between dam IGF-1 concentrations and lamb birth weight. The IGF-1 selection lines provide an opportunity to further explore the relationship between lamb birth weight and ewe behaviour and its affect on lamb rearing performance. This project investigates whether Romney ewe temperament, as shown by their arena behaviour and subsequent maternal behaviour and lamb rearing performance differs between genetically divergent selection lines for maternal IGF-1.

# 8.3 Materials and Methods

## 8.3.1 Animals and Measurements

A flock containing selection lines of sheep with high and low plasma concentrations of IGF-1 was established in 1986 from a commercial population of Romney sheep. Three lines of sheep were generated based on plasma concentrations of IGF-1 so that after five generations of divergent selection for IGF-1 plasma concentration, measured at 4 months of age, the High line have IGF-1 levels 30% higher (High IGF) than the Control line (Control) and the Low line have IGF-1 levels 25% less (Low IGF) than the Control line (Blair *et al*., 2002).

The ewes pregnancy scanned with single and twin lambs in the 2002 lambing season were used in this study. Primiparous (2-tooth; 2 year old ewes) ewes (28 High IGF, 26 Control and 31 Low IGF) and multiparous (mixed age; older than 2 years) ewes (60 High IGF, 39 Control and 50 Low IGF) were used. Ewes were randomly selected from each of the High IGF and Low IGF selection lines and had been mated to either High IGF or Low IGF rams. The Control ewes were mated to Control rams.

The study was carried out on a Massey University research farm (Keebles), which operates under commercial conditions. The animals included in the trial were performance recorded and were monitored intensively from mating through to lamb weaning. All ewes were run together over this period.

The trial ewes were single sire mated from the $12^{th}$ March to the $25^{th}$ April. Liveweight and body condition score were recorded for each of the ewes prior to mating. Mating harnesses were used and the raddle colour changed every fourteen days. Ewes were pregnancy scanned on the $18^{th}$ June by a Real-time Ultrasound Scanner to diagnose foetal number.

The ewes were arena tested in the first week of July (average 53 days before lambing). The mean lambing date was $26^{th}$ August. Within 12 hours of birth lambs were weighed, sexed, ear-tagged and identified to the dam. A Maternal Behaviour Score (MBS) previously described by O'Connor *et al.* (1985) was recorded on each ewe when her lambs were tagged (Table 8.1).

The litter size was recorded at tagging and weaning (21st November; mean lamb age 87 days). Litter survival was measured from scanning to tagging and tagging to weaning and was calculated by dividing the later litter size by the former litter size and recorded as a percentage. Weight of lamb weaned was recorded for each ewe. Ewes that lost an entire litter were included in the analysis as rearing zero kg of lamb to weaning.

### 8.3.2 Behaviour Tests

The MBS was scored on a 5-point scale based on the distance a ewe retreats from her lambs when the shepherd is tagging them (Table 8.1).

*Table 8.1 The maternal behaviour scores at tagging and the number of animals used in this study (proportion of animals in dam selection line with MBS).*

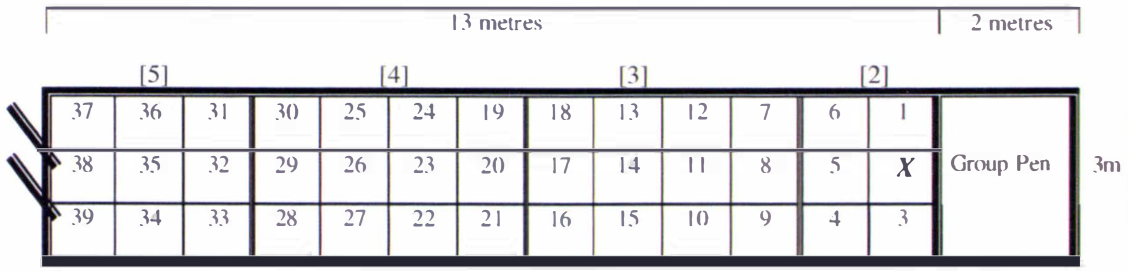
| Description of Maternal Behaviour Score (MBS)[1] | MBS | High IGF | Control | Low IGF |
|---|---|---|---|---|
| Ewe flees as the shepherd approaches, shows no interest in lambs, does not return | 1 | 2 (4%) | 7 (20%) | 2 (4%) |
| Ewe retreats further than 10 metres, comes back to her lambs as the shepherd leaves | 2 | 15 (27%) | 9 (26%) | 19 (35%) |
| Ewe retreats to such a distance that tag identification is difficult (5-10 metres) | 3 | 21 (37%) | 9 (26%) | 16 (29%) |
| Ewe retreats but stays within 5 metres | 4 | 9 (16%) | 7 (20%) | 8 (14%) |
| Ewe stays close to the shepherd during handling of her lambs | 5 | 9 (16%) | 3 (8%) | 10 (18%) |

[1] as described by O'Connor *et al.* (1985).

The Arena Behaviour Test was first used by Fell and Shutt (1989) on groups of ewes. In this study it was modified to test individual rather than groups of sheep (Kilgour, 1998), because a solitary sheep will probably experience a greater degree of conflict between joining a flock and avoiding a person. We also want to be able to select individual sheep for animal breeding purposes. The arena test used in this study was further modified when compared to the test used by Kilgour (1998) with the main difference being the shortened recording time from 10 to 5 minutes.

Each test sheep was placed into an enclosed arena measuring 3m x 13m (Figure 8.1), and its behaviour was recorded for 5 minutes. The sides of the arena were solid and high enough to stop the sheep jumping out. The grid lines and numbers were marked on the floor of the arena with spray paint. The sheep entered the pen through a gate at square 38. The group pen at the end of the arena contained ten "Group" sheep. The barrier between the pen and the arena was a gate made from metal bars. The test sheep had visual contact with the "Group" sheep whilst in the arena. The person (shown as **X** in Figure 1) stood in front of the pen containing the "Group" sheep.

*Figure 8.1. Arena configuration for arena behaviour test.*




X=Person. Grid square = 1m x 1m

The test sheep was moved into the arena through the gate located at square 38 and during the test was allowed to move around in the arena for 5 minutes. The person standing at position **X**, recorded which grid square the sheep's left front foot was in at 15-second intervals. This gave an indication of how mobile the test sheep was. The conflict the test sheep experiences between joining a flock ("Group" sheep) and avoiding the person was quantified, according to Kilgour (1998). Forty test sheep were randomly selected for testing each day. Each sheep was tested only once and after testing it was released back to pasture. The "Group" sheep were from the same flock and were not pregnant. The "Group" sheep consisted of ten sheep, randomly selected each day. The same "Group" sheep were used daily and for a maximum of 4 hours a day throughout the trial.

A total of 20 readings were recorded over the five minute testing period. These readings were used to determine the following parameters for each ewe:

- Maximum distance, being the furthest square from position **X** (max)
- Minimum distance, being the closest square to position **X** (min)
- Mean distance from position **X** (mean)
- Total distance covered (total)

Additional characteristics recorded included the number of times the ewe defecated, urinated, high or low-pitch bleated throughout the 5 minute test period.

In addition the following measurements were calculated:

- Proportion of time in Zone 5 (square 31 to 39)
- Proportion of time in Zone 4 (square 19 to 30)
- Proportion of time in Zone 3 (square 7 to 18)
- Proportion of time in Zone 2 (square 1 to 6)
- Time to first enter Zone 3 (minutes)
- Time to first enter Zone 2 (minutes)
- Time to start sniffing "Group" sheep (minutes)
- Number of times test sheep sniffed "Group" sheep (tally)

For each ewe the date of arena test, time of test and days from parturition was also recorded.

### 8.3.3 Statistical Analyses

Data collected were used to compare dam selection lines using PROC MIXED (SAS, 2002). PROC MIXED uses restricted/residual maximum likelihood (REML) methods to estimate the random effect (SAS, 2002). The analysis was constrained by the number of animals in each of the fixed effects, therefore restricting the analysis to the following univariate mixed linear model, which tested for the fixed effect of dam selection line. Preliminary analyses were aimed at identifying which fixed effects should be included in the linear models for the main analyses. Preliminary analyses tested the significance of age of dam and litter size at birth as fixed effects for behaviour traits and lamb rearing performance analyses. The fixed effect of sire selection line was tested for lamb performance analyses. The fixed effects were only retained in the model if significant at $P<0.05$.

To help decide the pathways involved in the differences in dam behaviour and lamb rearing performance, analyses of covariance were performed and were retained in the model if statistically significant at $P<0.05$.

The following linear model was used:

$$Y_{ij} = \mu + L_i + L_i{*}\beta_l X_{ij} + e_{ij}$$

where $Y_{ij}$ is the record of the j[th] dam of the i[th] selection line,

$\mu$ is the general mean,

$L_i$ is the fixed effect of the i[th] dam selection line,

$X_{ij}$ is the behaviour trait measured (e.g. minimum distance from X) in the i[th] dam of the j[th] selection line,

$\beta_l$ is the regression of the production trait of interest (e.g. weight of lamb weaned) on the behaviour trait (e.g. minimum distance from X), and

$e_{ij}$ is the random residual effect unique to $Y_{ij}$,.

Multiple comparisons between least squares means for the main factors affecting the trait of interest were performed.

Chi-squared ($\chi^2$) analyses were performed for binary behaviour traits using the SAS procedure for categorical data modelling, PROC CATMOD (SAS, 2000).

Pearson correlation coefficients (*r*) were computed using SAS (PROC CORR) for behaviour and production traits across all animals and within dam selection line and were reported if significant at P<0.10.

# 8.4 Results

## 8.4.1 Arena Test Behaviour

The Control ewes differed from the High IGF and Low IGF ewes for a number of behaviours in the arena test (Table 8.2). The Control ewes moved closer to the person compared with the High IGF and Low IGF ewes (Table 8.2). The date of the arena test had a significant effect on mean distance from the person (P<0.01). Mean distance was significantly less on the first day of testing compared to latter days. A possible reason for this was that the "Group" sheep may have been less settled on the first day and were therefore interacting more with the test sheep.

Control ewes with twins remained closer to the person than the High and Low IGF ewes with twins (High P<0.05; Low P<0.01) (Figure 8.2). The High IGF and Low IGF ewes tended to travel further from the person if they had twins compared to those that had a single foetus (P>0.05). This trend was reversed for the Control ewes (P=0.13).

*Table 8.2 The effect of dam selection line on movement within the arena (least squares mean ± standard error). Means within dam selection line having different superscripts are different (P<0.05).*

| Trait | High IGF | Control | Low IGF |
|---|---|---|---|
| Total distance travelled (m) | 58 ± 3.92 [a] | 66 ± 4.53 [a] | 57 ± 4.05 [a] |
| Mean distance from person (m) | 13.1 ± 0.56 [a] | 11.3 ± 0.66 [b] | 14 ± 0.59 [a] |
| Minimum distance from person (m) | 6.4 ± 0.51 [a] | 4.6 ± 0.59 [b] | 6.9 ± 0.53 [a] |
| Maximum distance from person (m) | 28.8 ± 0.62 [a] | 26.8 ± 0.71 [b] | 29.6 ± 0.64 [a] |
| Time to Zone 2 (minutes) | 1.3 ± 0.17 [a] | 1.3 ± 0.17 [a] | 1.3 ± 0.19 [a] |
| Time to Zone 3 (minutes) | 0.52 ± 0.072 [a] | 0.46 ± 0.08 [b] | 0.69 ±0.073 [a] |
| Proportion of time in Zone 5 | 5% ± 0.013 [a] | 2% ± 0.015 [a] | 8% ± 0.014 [b] |
| Proportion of time in Zone 4 | 18% ± 0.02 [a] | 15% ± 0.02 [a] | 16% ± 0.02 [a] |
| Proportion of time in Zone 3 | 56% ± 0.03 [a] | 52% ± 0.04 [a] | 58% ± 0.03 [a] |
| Proportion of time in Zone 2 | 21% ± 0.03 [a] | 31% ± 0.04 [b] | 18% ± 0.03 [a] |

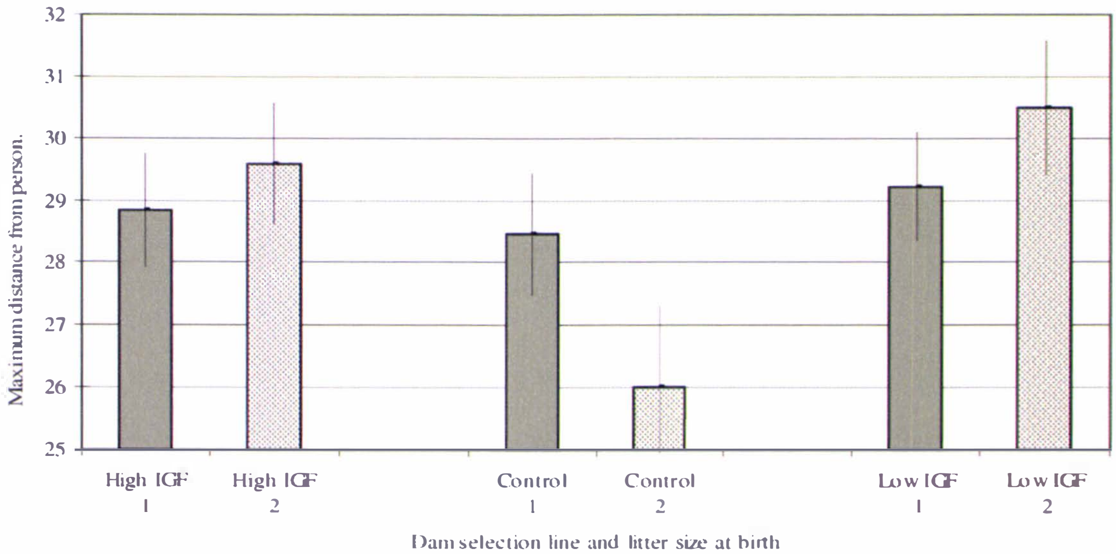
Mixed age High and Low IGF ewes moved further from the person than mixed age Control ewes (High P<0.05; Low P<0.01).

All ewes spent a far greater proportion of time in Zone 3 than any other zone within the arena (Table 8.2, Figure 8.3). The Low IGF ewes spent significantly longer time in Zone 5 than the High IGF and Control ewes. The Control ewes spent significantly longer in Zone 2, close to the person and the "Group" sheep, than the Low and High IGF ewes (Table 8.2). The date of the arena test had a significant effect on proportion of time in Zone's 4 and 2 (P<0.05 and P<0.01 respectively) with ewes tested on the first day spending significantly less time in Zone 2 and more time in Zone 4 than day 3 onwards. Once again, this may be because the "Group" sheep were more settled on latter test days as they had become more familiar with their surroundings and to the person. The hour of the arena test significantly affected proportion of time in Zone's 2 and 3 (P<0.05), with ewes tested in the morning spending more time in Zone 3 and less time in Zone 2 than ewes tested in the afternoon.

The proportion of sheep that entered Zone 2, differed significantly between High and Low IGF ewes (P<0.01); 72% of the Control ewes entered Zone 2 compared with 52% of the High IGF ewes and 43% of the Low IGF ewes. However for those ewes that entered Zone 2, the mean time taken to enter was the same for High and Low IGF ewes

(Table 8.2). The date of arena test ($\beta$=0.18 ± 0.076, P<0.05) and mating weight ($\beta$=-0.05 ± 0.014, P<0.001) had significant effects on time taken to enter Zone 2.

*Figure 8.2. The effect of litter size at birth and dam selection line on maximum distance from the person (standard errors included).*




The Control ewes approached Zone 3 quicker than the High and Low IGF ewes (Table 8.2). The High IGF ewes tended to approach Zone 3 faster than the Low IGF ewes (P=0.09). Mixed age ewes (0.46 ± 0.054 minutes) approached Zone 3 faster than 2 year old ewes (0.65 ± 0.071 minutes) (P<0.05).

The Control ewes were more likely to sniff the "Group" sheep through the metal gate than the High IGF and Low IGF ewes and sniffed more times on average than the Low IGF ewes. The hour of arena test had a significant effect on this trait ($\beta$=0.14 ± 0.067, P<0.05) with ewes tested in the afternoon sniffing the "Group" sheep nearly twice as much as ewes tested in the morning (Table 8.3).

The Low IGF ewes were more likely to high bleat within the arena than the Control and High IGF ewes. Generally the same proportion of 2 year old ewes high bleated as did not, however mixed age ewes were more likely not to high bleat. This trend was significant for the Control ewes (P<0.01) where 77% of mixed age ewes did not high bleat. Low bleating was similar between dam lines.

One third of the High IGF ewes urinated in the arena compared to 20% of the other ewe lines. There were no differences between lines in number of defecations during the arena test (Table 8.3).

*Table 8.3 The effect of dam selection line on social behaviour within the arena (least squares mean ± standard error). Means within dam selection line having different superscripts are different (P<0.05).*

| Trait | High IGF | Control | Low IGF | P ($\chi^2$) |
|---|---|---|---|---|
| Proportion that sniffed group sheep | 28% | 37% | 18.5% | P<0.05 |
| Time to sniff (minutes) | 1.8 ± 0.25 [a] | 1.5 ± 0.25 [a] | 1.2 ± 0.33 [a] | |
| Tally of sniffs to group sheep | 1 ± 0.27 [a] | 1.7 ± 0.32 [a] | 0.7 ± 0.28 [b] | |
| Proportion that high bleat | 34% | 37% | 57% | P<0.01 |
| High bleats tally | 1.9 ± 0.56 [a] | 2.7 ± 0.65 [a b] | 3.9 ± 0.58 [b] | |
| Proportion that low bleat | 40% | 35% | 43% | ns |
| Low bleats tally | 1.7 ± 0.33 [a] | 1.2 ± 0.38 [a] | 1.4 ± 0.34 [a] | |
| Proportion that urinated | 32% | 21% | 19.5% | P<0.05 |
| Proportion that defecated | 6% | 6% | 6% | ns |

## 8.4.2 Maternal Behaviour

Control ewes tended to have a lower mean MBS (2.7 ± 0.19) than the High IGF (3.1 ± 0.16) and Low IGF ewes (3.1 ± 0.16) (P=0.09) (Table 8.1). MBS was significantly affected by age of dam, dams born in 1997 and 1998 having significantly higher maternal behaviour scores at tagging than dams born in 1999 and 2000 ($\beta$=-0.64 ± 0.196, P<0.01).

For all ewes measured during the arena test, behaviours measured did not have a significant effect on MBS (P>0.05). Further analyses were performed to determine if differences in MBS could be explained by arena behaviour. The model was modified to include the fixed effects of whether a ewe did or did not enter Zone 2, or did or did not high bleat during the arena test. These arena behaviours had no significant effect on MBS (P>0.05). Therefore, correlations were performed to determine if a relationship exists between arena behaviour and MBS. High IGF ewes with higher MBS spent longer in Zone 5 ($r$=0.30; P<0.05) had higher mean distance ($r$=0.28, P<0.05), maximum distance ($r$=0.26, P=0.06) and minimum distances ($r$=0.21, P=0.13) from the person. Therefore High IGF ewes with higher MBS have lower flocking tendency in the arena test. However Low IGF ewes that spent longer in Zone 2 tended to have higher

MBS at tagging ($r$=0.21, P=0.12). No significant correlations existed for Control ewes between MBS and arena behaviours (P>0.10) (Appendix 8.7, Table 8.7.1).

Zones were introduced to the Arena test in an attempt to investigate their use as a predictor for MBS at tagging. A smaller proportion of Control ewes spent time in Zone 5, farthest from the person and the "Group" sheep, and fewer Control ewes had an MBS of 5 (Figure 8.3 and 8.4). A greater proportion of the Control ewes had a combined MBS of 1 and 2 and a larger proportion of these ewes spent time in Zone 2 compared with the High and Low IGF ewes. There was a tendency for ewes that spend longer in Zone 5 during the arena test to have higher MBS.

*Figure 8.3 Proportion of time spent High IGF, Control and Low IGF ewes in arena zone.*

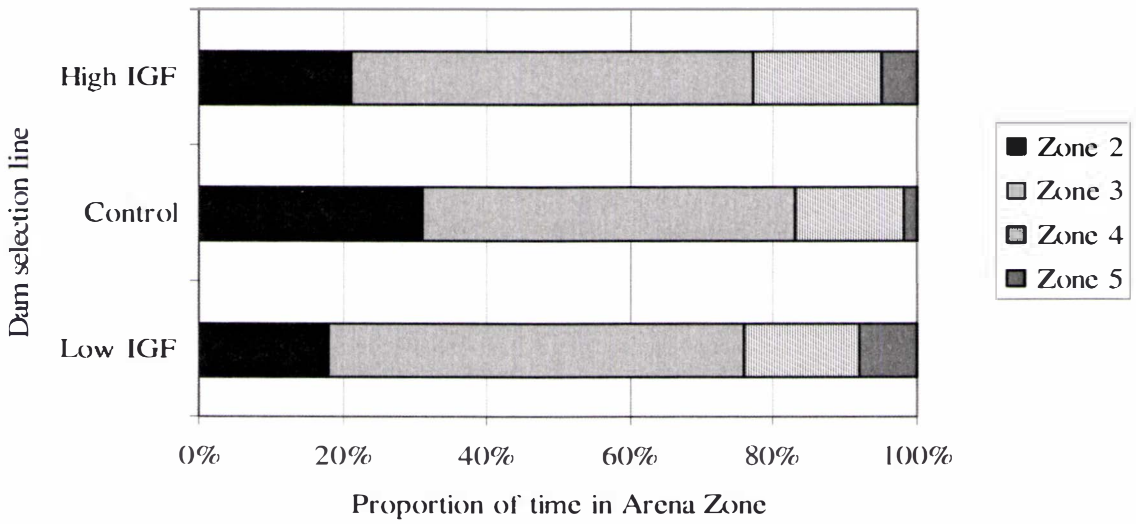
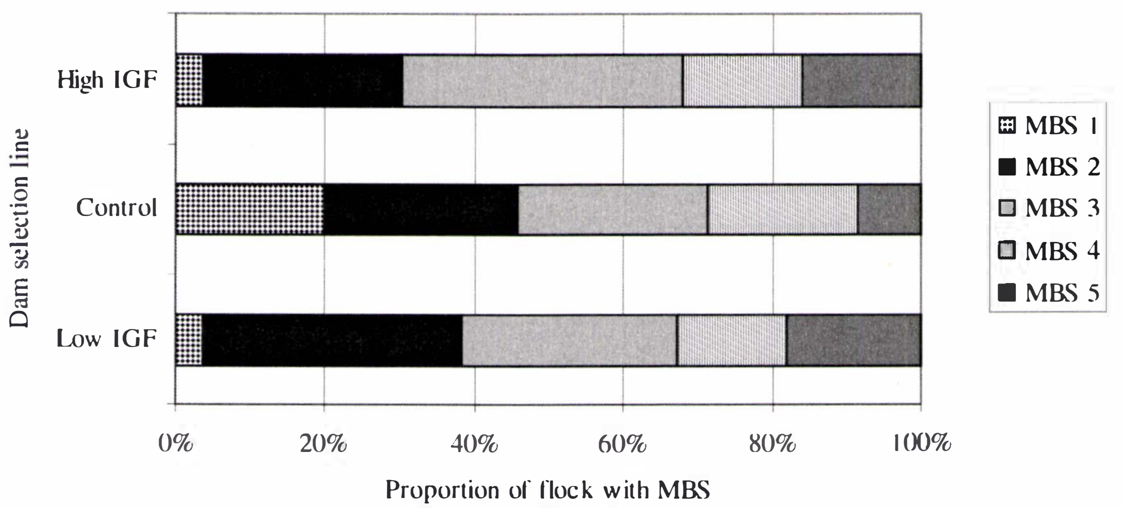



*Figure 8.4 Proportion of High IGF, Control and Low IGF ewes with MBS.*



### 8.4.3 Lamb Rearing Performance

Litter weight at birth differed significantly between the High IGF and Low IGF ewes and the Control ewes were intermediate (Table 8.4). The Low IGF ewes had heavier litters than High IGF ewes. Other lamb production traits were similar between lines (Table 8.4). Sire IGF-1 line was not a significant effect on lamb production traits and was therefore excluded from the analyses. Litter size at birth significantly affected litter weight at birth ($\beta$=3.54 ± 0.215, P<0.0001). Litter size at weaning was significantly affected by litter weight at birth ($\beta$=0.15 ± 0.021, P<0.0001).

Litter survival to tagging and weaning was similar between 2 year old and mixed age ewes (P>0.05). For all sheep, litter size and weight of lamb at weaning was similar between 2 year old and mixed age ewes however Low IGF mixed age ewes reared 1.2 ± 0.09 lambs and 22 ± 1.67kg, whilst Low IGF 2 year old ewes reared 0.9 ± 0.14 lambs and 15 ± 2.52kg (P<0.05).

The High IGF ewes tended to wean heavier lamb weights than the Low IGF ewes (P=0.12) (Table 8.4). Litter weight at birth ($\beta$=2.54 ± 0.389, P<0.0001) and ewe condition score at mating ($\beta$=4.12 ± 1.70, P<0.05) significantly affected weight of lamb weaned, so that ewes with higher condition scores at mating and higher litter weights at birth weaned greater lamb weights. The effect of litter weight at birth on weight of lamb weaned differed between dam selection lines (P<0.0001). The effect of litter weight at birth was greatest in the High IGF line ($\beta$=3.41 ± 0.658, P<0.0001), slightly lower in the Control line ($\beta$=3.28 ± 0.888, P<0.001) and lowest in the Low IGF line ($\beta$=1.62 ± 0.559, P<0.01). Weight of lamb weaned was heavier for all ewes with heavier litter weights at birth, however the relationship was strongest for the High IGF ewes (correlations in Table 8.4).

*Table 8.4 The effect of dam selection line on lamb rearing performance (least squares mean ± standard error). Means within dam selection line having different superscripts are different (P<0.05).*

| Trait | High IGF | Control | Low IGF |
|---|---|---|---|
| Litter size at birth | 1.5 ± 0.06 [a] | 1.4 ± 0.07 [a] | 1.4 ± 0.06 [a] |
| Litter size at weaning | 1.2 ± 0.07 [a] | 1.06 ± 0.09 [a] | 1.07 ± 0.07 [a] |
| Litter survival to tagging | 0.93 ± 0.03 [a] | 0.95 ± 0.03 [a] | 0.95 ± 0.03 [a] |
| Litter survival to weaning | 0.85 ± 0.04 [a] | 0.80 ± 0.05 [a] | 0.83 ± 0.05 [a] |
| | | | |
| Dam litter weight at birth (kg) B | 5.6 ± 0.17 [a] | 5.9 ± 0.21 [ab] | 6.2 ± 0.18 [b] |
| Dam litter weight at weaning (kg) W | 24.1 ± 1.43 [a] | 21.6 ± 1.54 [a] | 20.7 ± 1.54 [a] |
| Correlation between B and W | 0.63 (P<0.0001) | 0.45 (P<0.01) | 0.37 (P<0.01) |

Further analyses were performed to determine if differences in lamb rearing performance could be explained by arena behaviour. The model was modified to include the fixed effects of whether a ewe did or did not enter Zone 2, or did or did not high bleat during the arena test. These arena behaviours had no significant effect on litter weight at birth, weight of lamb weaned and litter survival to weaning (P>0.05). Whether a ewe high bleated during the arena test did not significantly affect litter survival at tagging (P>0.05). A significant interaction was found between litter size at birth and whether a ewe did or did not enter Zone 2. These results are presented in Table 8.5.

*Table 8.5 The effect of litter size at birth and whether a ewe does or does not enter Zone 2 in the arena behaviour test, on litter survival at tagging (least squares mean ± standard error).*

| Litter size at birth | Ewe does enter Zone 2 | Ewe does not enter Zone 2 | P (behaviour) |
|---|---|---|---|
| Single | 0.92 ± 0.027 | 0.98 ± 0.031 | ns |
| Twins | 1.0 ± 0.036 | 0.89 ± 0.034 | * |
| P (litter size) | ns | ns | |

ns=not significant at P<0.05, * P<0.05, **P<0.01, ***P<0.0001.

Ewes with twin litters that do not enter Zone 2 during the arena test had significantly lower litter survival at tagging (Table 8.5). Ewes that move around more in the arena are more likely to enter Zone 2. Ewes that did enter Zone 2 travelled 68.4 ± 2.49m and ewes that did not enter Zone 2 travelled 52.9 ± 2.76m (P<0.0001), however total distance travelled in the arena did not significantly affect litter survival to tagging (P>0.05).

Correlations were performed to determine if there were any relationships between behaviours and lamb rearing performance. MBS increased with litter weight at birth for all ewes ($r$=0.25, P<0.01) and for Low IGF ewes ($r$=0.40, P<0.01), but had no significant relationship in Control and High IGF ewes (P>0.10). Litter weight at birth was heavier in High IGF ewes that took longer to enter Zone 3 ($r$=0.25, P=0.07) and heavier in Control ewes that had lower maximum distances to the person ($r$=-0.32, P<0.05). Litter survival traits and weight of lamb weaned were not significantly affected by MBS (P>0.05).

For all animals, ewes that high bleated fewer times in the arena test had higher litter survival rates to weaning ($r$=-0.15, P<0.05). Ewes that lost an entire litter by weaning high bleated twice as much during the arena test than ewes whose litter survived (5 ± 0.9 vs 2.7 ± 0.5, P<0.05). High-pitched bleating during the arena test did not significantly predict MBS (P>0.05).

Control ewes had higher litter survival rates at weaning if they were slower to enter Zone 2 ($r$=-0.28, P=0.10). There were no significant correlations for High IGF ewes between litter survival rate at weaning and arena behaviours (P>0.10). Low IGF ewes that spent less time in Zone 5 ($r$=-0.28, P<0.05), high bleated less ($r$=-0.23, P=0.06), travelled closer to the person (minimum distance $r$=-0.20, P=0.11) and moved around more in the arena (total distance $r$=0.21, P=0.09) had higher litter survival rates at weaning. Ewes that move around more in the arena are more likely to enter the squares closer to the person and this may explain why Low IGF ewes with higher litter survival travelled closer to the person.

Across the flock, ewes that had high bleated more in the arena test tended to wean less lambs ($r$=-0.12, P=0.10). This relationship was observed in the Low IGF ewes ($r$=-0.21, P=0.10) but not the High IGF or Control ewes. Low IGF ewes weaned heavier lamb weights if they moved more (total distance $r$=0.31, P<0.05) in the arena. Control ewes that weaned heavier lamb weights were slower to enter Zone 2 in the arena test ($r$=-0.32, P=0.06). High IGF ewes tended to wean heavier lamb weights if they were quick to enter Zone 3 ($r$=0.20, P=0.11).

## 8.5 Discussion

Movement within the arena was generally similar between High and Low IGF ewes. The unselected Control ewes showed stronger flocking behaviour than the High and

Low IGF ewes in the arena behaviour test and the MBS. The Control ewes were less perturbed by the person in the arena. They had lower mean, minimum and maximum distances recorded; approached Zone 3 at a faster speed. Greater proportions of Control ewes entered Zone 2, spent a greater proportion of time in Zone 2 and were more likely to interact with the Group sheep. Kilgour's unselected flock also travelled significantly greater distances and had lower minimum distance at 12 months of age than the Fertility flock selected for lamb rearing ability (Kilgour, 1998).

Low IGF ewes had significantly higher litter birth weights than High IGF ewes as found by Blair and co-workers (2002). Control ewes were intermediate. The weight of lamb weaned was not significantly different between dam selection lines, however High IGF ewes tended to wean heavier lamb weights than Low IGF and Control ewes, therefore it can be extrapolated that High IGF lambs grew faster from birth to weaning, as litter size at birth and weaning were similar between selection lines. These results are consistent with that of Blair *et al.* (2002).

The behaviour in the arena test suggests that Low IGF ewes experience greater levels of stress than High IGF ewes and that this is reflected in their lamb rearing performance. Low IGF ewes were more likely to high bleat and high bleat more often than High IGF and Control ewes and a greater proportion of Low IGF ewes spent longer in Zone 5, farthest from person and "Group" sheep. Murphy *et al.* (1994b) reported that animals of quiet temperament grow faster and are better producers than animals that are restless, nervous or aggressive animals. In this study Low IGF ewes had heavier litter weights at birth, however this did not translate into heavier weights of lamb weaned, suggesting that High IGF ewes have better lamb rearing abilities than Low IGF ewes.

The relationship between arena behaviour traits and MBS was not strong for all ewes, however High IGF ewes that showed less flocking tendency in the arena also had higher maternal behaviour scores at tagging. The strongest correlated arena behaviour with MBS was proportion of time spent in Zone 5 so that High IGF and Low IGF ewes that spent longer in Zone 5, farthest from the person and "Group" sheep, had higher MBS. This correlation was moderate and significant for High IGF ewes but not significant for Low IGF. Murphy *et al.* (1994b) reported a similar result where their ewes that spent the most time in the zone closest to the person and pen of sheep in a different arena test, travelled further from their lambs when they were ear-tagged ($r$=-0.35). However, Murphy and co-workers weighted the time spent in each zone by multiplying the time in each zone by the number of the zone (Murphy *et al.*, 1994b). Low IGF ewes with heavier litter weights at birth had higher MBS. This relationship was only significant for Low IGF ewes suggesting that different physiological or genetic mechanisms within High and Low IGF ewes determine resultant MBS at tagging. The analyses in this study involving MBS must be considered with caution as some MBS values had few animals (Table 8.1).

Kilgour (1998) showed that arena behaviours were important predictors for lamb survival. Kilgour and Szantar-Coddington (1995, 1997) and Kilgour (1998) reported differences in the total distance travelled and the number of bleats in ewes selected for greater fertility when compared to a random selected control flock. Fertility ewes bleated less, whether the bleat was high or low pitched was not defined and the number of bleats by Merino sheep far exceeded that of the Romneys in this study by at least 10-fold (Kilgour, 1998). This study failed to show differences in total distance travelled between dam selection lines, however ewes that high pitch bleated less had higher litter survival rates to weaning. This relationship was significant for all ewes. High pitch bleating in the arena test could be used as a potential indicator for lamb rearing performance in Low IGF ewes, as Low IGF ewes that high bleated less weaned heavier lamb weights.

In this study ewes with twins had higher litter survival rates at tagging if they did enter Zone 2. This may be because ewes that travel greater distances in the arena are more likely to enter Zone 2. In this study ewes that did enter Zone 2 travelled 16m further than ewes that did not enter Zone 2. However Kilgour (1998) showed that the fertility ewes travelled 60% less than the random flock in their arena test. Control ewes that were slower to enter Zone 2 had higher litter survival rates and weaned heavier lamb weights per ewe. Low IGF ewes that moved more in the arena tended to have higher litter survival rates and wean more lamb. This latter observation is harder to explain as ewes that remain longer on their birth site and therefore do not move around much tend to have higher lamb survival rates (Cloete *et al.*, 1998b), however Pollard (1989) showed that when separated, ewes rearing multiple litters travelled greater distances towards their lambs compared with ewes rearing singles.

The arena test used in this study differed from that of Kilgour and Szantar-Coddington (1995, 1997) and Kilgour (1998). Their arena test time was ten minutes and the arena entry and exit gate was located 7m from the person. The shortened test time should not have affected the recorded observations as more variables were measured and derived in this study in an attempt to better explain sheep movement and behaviour, for example proportion of time spent in arena zones. The arena test in its current form is time consuming and requires a large labour input. To ensure high uptake by New Zealand farmers the useful arena behaviours identified in this study need to be incorporated into an existing farm management practice and investigated further to determine their feasibility as indicators for lamb rearing performance. A possible farm practice would be lamb weighing at weaning, lambs that show greatest aggression and flocking tendency in the weighing crate may have poorer lamb rearing performance as dams or rams. An effective test performed early in the animal's life cycle, that was moderately heritable and highly repeatable would improve lamb-rearing performance rapidly across the flock, as animals with poor temperament would be culled at a young age.

Dwyer *et al*. (1999b) showed that ewe breed affects maternal ovarian hormones during gestation and that changes in maternal oestradiol concentration are related to some aspects of maternal behaviour. Days from arena test to parturition did not affect the majority of arena behaviour traits recorded in our study. Therefore it is unlikely that hormonal changes in late pregnancy affect the behaviour traits tested, making application of the arena test suitable at any time of the ewe's life cycle.

In this study, it appears that temperament differs between animals selected for High and Low IGF and the unselected Control flock and it may be that an increase in intensification and selection for a physiological characteristic, such as IGF-1, has led to a decrease in the expression of behaviours associated with increased birth weight and survivability under extensive conditions (Dwyer and Lawrence, 1998a).

## 8.6 Conclusion

No relationship could be found between IGF-1 selection line, birthweight, maternal behaviour and lamb rearing performance. However there appears to be links between the flocking behaviour of Romney sheep and their IGF-1 status. There was an expected birthweight difference between IGF-1 selection lines and this did have an affect on flocking behaviour but not on maternal behaviour. Low IGF, High IGF and Control ewes differ consistently in some behaviours during the arena test.

It appears that arena behaviour, in particular lack of high-pitched bleating and reduced flocking behaviour, are predictors for lamb rearing performance. However, further arena tests need to be performed on groups of ewes that differ markedly in flocking and subsequently maternal behaviour to determine if these arena behaviours are suitable and reliable predictors for maternal behaviour and lamb rearing performance. Only then can the results and trends reported in this study be validated and applied to Industry.

Arena Behaviour Tests on Finn and Texel ewes warrant investigation as there was sufficient variation in maternal behaviour within and between these breeds as shown in Chapter 6 and Chapter 7.

# 8.7 Appendix

*Table 8.7.1 Correlation coefficients between measures of arena and maternal behaviour and lamb production traits for dam selection lines.*

Where B=Dam litter weight at birth; ST= Litter survival from birth to tagging; SW= litter survival to weaning; W= dam litter weight at weaning and MBS=maternal behaviour score. Only statistically significant correlations are reported (P<0.10).

| Behaviour traits | All | High IGF | Control | Low IGF |
|---|---|---|---|---|
| Maximum distance from person | | MBS 0.26 § | B –0.32 * | |
| Minimum distance from person | | | | ST –0.25 *<br>SW –0.20 § |
| Mean distance from person | | MBS 0.28 * | | |
| Total distance travelled | | | | SW 0.21 §<br>W 0.31 * |
| Proportion of time in Zone 2 | | | | |
| Proportion of time in Zone 3 | | | | ST 0.30 * |
| Proportion of time in Zone 4 | | | | |
| Proportion of time in Zone 5 | | MBS 0.30 * | | ST –0.41 ***<br>SW –0.28 * |
| Time to sniff Group sheep | | | ST –0.57 * | |
| Time to Zone 2 | ST –0.18 § | | ST –0.40 *<br>W –0.32 §<br>SW –0.28 § | |
| Time to Zone 3 | | B 0.25 §<br>W 0.20 § | | |
| Low bleats | | | | |
| High bleats | W -0.12 §<br>SW –0.15 * | | | W –0.21 §<br>SW –0.23 § |
| MBS | B 0.25 ** | | | B 0.40 ** |

§ P<0.10, * P<0.05, **P<0.01, ***P<0.0001.

CHAPTER 9

# The effect of pasture allowance during pregnancy on maternal behaviour and lamb rearing performance in highly fecund ewes

*Photograph taken by Julie Everett-Hincks*

Related publications:

Everett-Hincks *et al*. (2004). The effect of pasture allowance during pregnancy on maternal behaviour and lamb rearing performance in highly fecund ewes. *Submitted to Livestock Production Science, Cambridge*.

## 9.1 Summary

This study investigated the behaviour and performance of ewes with twins and triplets on post-grazing sward heights of 2, 4, 6 and 8cm in late pregnancy and at lambing. Lamb behaviour and performance was also investigated.

Twin litter weight at birth was similar for ewes grazing 2, 4 and 6 cm sward heights. Increasing pasture allowance from just 2cm to 4cm to ewes with triplet litters increased litter weight at birth by 2kg, increased weight of lamb weaned by 8kg and improved litter survival to tagging by 4%. Triplet lamb survival to tagging increased by 15% from the lowest pasture allowance to the highest (from 2cm to 8cm). Triplet litter survival was similar to twin litter survival at the highest pasture allowance (8cm; 2000 kgDM/ha).

Pasture allowance had a greater effect on lamb behaviour than ewe behaviour and triplets were more affected than twins. Feeding level did not affect Maternal Behaviour Score (MBS), however MBS was related to a number of lamb behaviours. Ewes on higher pasture allowances were more likely to stay with their litter at the tagging site. Ewes with triplet litters on the 2cm sward height were further from their litter five minutes after tagging and high pitch bleated significantly more. These ewes were less likely to make contact with their lamb after tagging. Triplets born on lower pasture allowances were less likely to stand, locate their dam's udder and follow their moving dam. Fewer triplet lambs bleated following tagging and this might be why fewer ewes made contact.

The behaviour of the ewe and lamb after separation, during tagging, show promise as indicators of lamb performance. In this study lamb growth rate increased 10g/day for every additional minute the lamb continued to lie on the ground after tagging. Lamb growth rate decreased by 10g/day for every minute longer the ewe took to contact her lamb after tagging.

It is important to consider the behaviour of both ewe and lambs as not 'poor' maternal behaviour but inadequate lamb behaviour may be the limiting factor in triplet lamb survival on lower pasture allowances. Triplet lambs on low pasture allowances were

less likely to bleat when separated from their dam, thus reducing the dam's ability to relocate her litter.

Ewes with triplets grazing high pasture allowances in late pregnancy can achieve litter survival rates similar to those with twins. Ewes with triplets require higher pasture allowances to achieve similar production as ewes with twin litters.

## 9.2 Introduction

Improved lambing percentage makes the biggest contribution to higher profits on New Zealand sheep farms (Geenty, 1997). Pregnancy scanning enables farmers to identify and preferentially feed ewes with multiple foetuses. However triplet lamb survival is a problem. Farmers require technology to improve lamb survival in highly fecund sheep. A ewe's maternal behaviour and litter survival are under minimal genetic control and the major source of variation in these traits is due to temporary environmental effects (Chapter 3). Lamb survival is predominantly controlled by the environment (Lopez-Villlalobos and Garrick, 1999; Morris *et al*., 2000; Chapter 3). Results from Chapter 4 suggest that ewes that maintain body condition in late pregnancy provide a more suitable environment to grow and support their litters and is particularly important for ewes with triplet litters. Therefore a better understanding of environmental conditions, particularly feeding levels throughout pregnancy and at lambing may influence the lamb losses seen in highly fecund ewes.

In late pregnancy and early lactation the nutritional requirements of ewes with twins are very high (Holmes, 1975). The last 4-6 weeks before lambing are critical (Scales *et al*., 1986). When multiple bearing ewes were offered additional feed in late pregnancy to increase liveweight, lamb mortality was reduced, suggesting merit in improved pre-lamb feeding for ewes carrying more than one lamb (Scales *et al*., 1986). To date 'optimal' pasture feeding levels for ewes with triplets have not been adequately defined as research into ewe energy requirements in late pregnancy has focused on ewes with singles and twins (Geenty and Rattray, 1987). Inadequate feeding can result in poor maternal behaviour, an important cause of lamb death (Nowak, 1996). Dwyer *et al*. (2003) demonstrated that a moderate reduction in maternal nutrition in late pregnancy resulted in a quantitative reduction in the expression of maternal behaviours, in particular MBS, at parturition under intensive indoor conditions. The New Zealand sheep industry is pasture based and the strength of ewe-lamb attachment for ewes with twin and triplet litters grazing differing pasture allowances in late pregnancy is unknown.

Ewe-lamb bonding and lamb survival are maximised by management practices that increase the time spent on the birth site by the ewe after parturition (Nowak, 1996). If pasture quality and quantity are good and the paddock has adequate shelter then the ewe will stay at the birth site with her lambs for a longer period (Pollard and Littlejohn, 1999). Lindsay *et al.* (1990) observed that the time spent on the birth site increased when ewes with twins were on a higher plane of nutrition 6 weeks before lambing. Nowak (1996) observed a considerable improvement in twin lamb bonding with their dam and twin lamb survival when the mother remained on the birth site for a minimum of 6 hours. However Murphy *et al.* (1994a) suggested that it is not that the dam is on the birth site for 6 hours after parturition that improves lamb survival but that the dam is together with all of her lambs. Nowak and Lindsay (1992) concluded that the ability of twin lambs to discriminate their dams from alien ewes 12 hours after birth is related to survival during the neonatal period and Shillito-Walser (1978) stated that the formation of the dam-lamb bond is the result of a rapid learning process influenced by both the behaviour of the dam and the lamb. Therefore lamb and maternal behaviour must be investigated conjointly to identify the environmental conditions that have the greatest impact on the formation of a successful ewe-lamb bond.

The arena behaviour test has been used in Australia to predict the lamb-rearing ability of Merino ewes (Kilgour, 1998). A modified arena behaviour test, similar to that described by Kilgour and Szantar-Coddington (1995) was performed to determine if behaviour characteristics in mid-late pregnancy differ in Romney ewes allocated different feeding levels. A relationship was sought between behaviour in the arena and maternal behaviour. Maternal behaviour score (MBS) has been positively associated with lamb weaning weight (O'Connor *et al.*, 1985; O'Connor, 1996), weight of lamb weaned and dam litter survival (see Chapters 3, 4 and 7).

This study investigates whether pasture allowance before and at lambing affects ewe behaviour, lamb behaviour and subsequent twin and triplet lamb performance to weaning.

# 9.3 Materials and Methods

## 9.3.1 Animals and Measurements

The animals included in the trial were monitored from pregnancy scanning through to lamb weaning. At pregnancy scanning (17$^{th}$ June; about day 64 of pregnancy) 186 first cycle-mated ewes (mated between the 9$^{th}$ and 26$^{th}$ of April) were identified as carrying twins (n=96) or triplets (n=90). Ewes were then transported from Massey University Riverside Farm to Massey University Keeble Farm. The trial ewes were made up evenly of mixed age and 2-tooth ewes and predominantly constituted Romney breed.

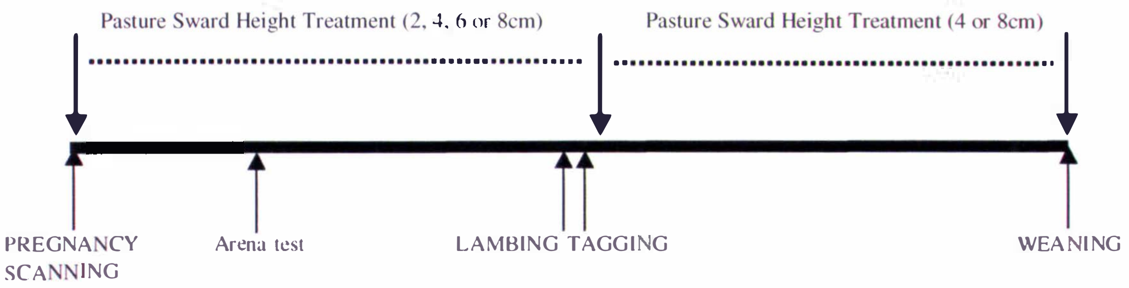
The ewes were randomly divided into four nutritional treatments (2, 4, 6 and 8cm post-grazing sward heights) representing a 'poor' (800 kgDM/ha), 'normal' (1200 kgDM/ha), 'generous' (1600 kgDM/ha and 'overgenerous' (2000 kgDM/ha) feed supply respectively (Rattray *et al*., 1987). Each treatment was replicated (n=12 ewes in each replicate during pregnancy) on two separate blocks ('Pines' and 'Caravan' blocks) to ensure statistical integrity (Table 9.1). The pasture height was measured weekly by rising plate meter method and maintained by modifying the stocking rate. The trial ewes remained on the four nutritional treatments during pregnancy and parturition and were removed after the lambs were ear-tagged (Figure 9.1).

*Table 9.1 Number of ewes included in statistical analysis according to post-grazing pasture sward height, block and litter size at birth.*

| | | Paddock | | | |
|---|---|---|---|---|---|
| Block | Litter size | 2cm | 4cm | 6cm | 8cm |
| 'Caravan' | Twins | 12 | 10 | 12 | 12 |
| | Triplets | 9 | 10 | 10 | 11 |
| | Paddock Total | 21 | 20 | 22 | 23 |
| 'Pines' | Twins | 12 | 12 | 13 | 12 |
| | Triplets | 11 | 11 | 8 | 11 |
| | Paddock Total | 23 | 23 | 21 | 23 |

Approximately 24 hours after the lamb was ear-tagged (tagging) the ewe and her lambs were transferred to one of two pastures with post-grazing sward heights of 4 and 8cm and remained on this feed level until lamb weaning (6th December 2002, mean lamb age 88 days) (Figure 9.1). This study focuses on pasture allowance up to and at tagging.

*Figure 9.1 Pasture sward height treatments and brief trial plan.*




The liveweight and body condition score of each ewe were recorded immediately following pregnancy scanning. Ewe liveweight was recorded immediately before transfer to the post-tagging nutritional treatment and at lamb weaning. Ewe liveweight change over lactation was calculated by subtracting ewe liveweight at lamb weaning from ewe liveweight post-tagging and dividing by the number of days. Ewe weight change was recorded in grams per day.

The ewes were arena behaviour tested from the 16th to the 20th of July (about day 90 of pregnancy). The ewes had been on the sward height treatments for one month when arena tests were performed (Figure 9.1).

The mean lambing date was the 9th September 2002. Weather conditions were mild and consistent throughout lambing. Date and hour of birth was recorded for each ewe and her litter. Within 12 hours of birth lambs (alive and dead) were caught, weighed, the lambs were sexed, ear-tagged and identified to the ewe. This procedure is referred to as 'tagging' and was performed by two people, one person measuring and the second person recording. Immediately following tagging the lambs were placed together on the ground, the two recorders moved 20-30m away where they recorded a number of maternal and lamb behaviours for a period of five minutes.

Litter size was recorded at pregnancy scanning, birth, tagging and weaning. Litter survival was measured from birth to tagging and tagging to weaning and was calculated by dividing the latter litter size by the former litter size and recorded as a percentage.

Litter survival from birth to weaning was also calculated. Litter weight at birth and weight of lamb weaned were recorded for each ewe. Ewes that lost an entire litter were included in the analysis as rearing zero kg of lamb to weaning.

Lamb survival was investigated as a lamb specific trait and was recorded at tagging and at weaning. Lamb survival was recorded as a binary trait, lambs alive at each of these stages was given a score of '1', whereas lambs not present at tagging or weaning were given a score of '0'.

Litter survival and lamb survival traits are related and were analysed separately in this study. Litter survival measures the dam's ability to rear all of her lambs born in a particular parity, while lamb survival is measuring an individual lamb's ability to survive and is influenced by the dam.

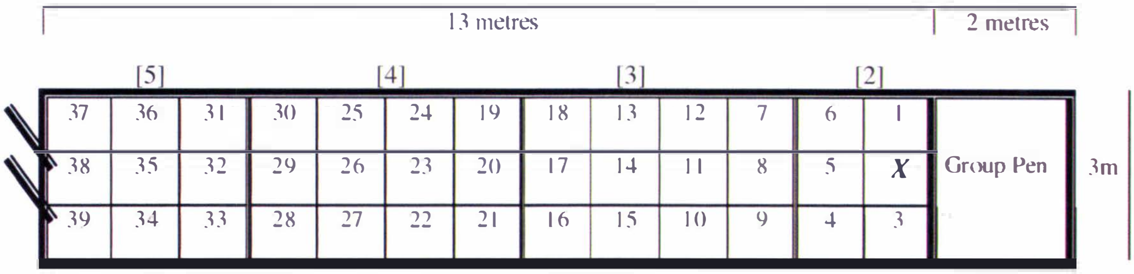
Lamb growth rate (grams/day) was calculated by subtracting birth weight from weight at weaning and dividing it by the number of days between the two measurements.

### 9.3.2 Arena Test Behaviour

The arena behaviour test was first used by Fell and Shutt (1989) on groups of ewes. In this study it was modified to test individual ewes rather than groups of sheep (Kilgour, 1998), because a solitary sheep will probably experience a greater degree of conflict between joining a flock and avoiding a person and we need to select individual animals for animal breeding programmes.

Each test sheep was placed into an enclosed arena measuring 3m x 13m (Figure 9.2), and its behaviour was recorded for 5 minutes. The observation time for the Arena Test was the same duration as the observation time allowed for the tagging behaviours (Section 9.3.4). The sides of the arena were solid and high enough to stop the sheep jumping out. The grid lines and numbers were marked on the floor of the arena with spray paint. The sheep entered the pen through a gate at square 38. The pen at the end of the arena contained ten "Group" sheep. The barrier between the pen and the arena was a metal gate, made of bars that enabled visual contact between the group and test sheep. The test sheep had visual contact with the "Group" sheep whilst in the arena. The person (shown as **X** in Figure 1) stood in front of the pen containing the "Group" sheep.

*Figure 9.2 Arena configuration for arena behaviour test.*




X=Person. Grid square = 1m x 1m

The test sheep was moved into the arena through the gate located at square 38 and during the test was allowed to move around in the arena for 5 minutes. The person standing at position **X**, recorded which grid square the sheep's left front foot was in at 15-second intervals. This gave an indication of how mobile the test sheep was and allowed the conflict the test sheep experiences between joining a flock ("Group" sheep) and avoiding the person to be quantified (Kilgour, 1998). Two paddocks of sheep were randomly selected for testing each day, one in the morning and one in the afternoon. Each sheep was tested only once and after testing it was released back to pasture. The "Group" sheep were from a different flock and were not pregnant. The "Group" sheep consisted of ten sheep, randomly selected each day and used daily for a maximum of 4 hours a day throughout the trial.

A total of 20 readings were made over the five minute testing period. These readings were used to determine the following parameters for each ewe:

- Maximum distance, being the furthest square from position **X** (max)
- Minimum distance, being the closest square to position **X** (min)
- Mean distance from position **X** (mean)
- Total distance travelled (total)

The number of times the ewe defecated, urinated, or bleated at a high or low-pitch throughout the test was recorded.

The following measurements were calculated from the data:

- Proportion of time in Zone 5 (square 31 to 39)
- Proportion of time in Zone 4 (square 19 to 30)
- Proportion of time in Zone 3 (square 7 to 18)
- Proportion of time in Zone 2 (square 1 to 6)
- Whether the ewe entered Zone 2 (yes/no)
- Time to first enter Zone 2 (minutes)
- Time to first enter Zone 3 (minutes)
- Time to start sniffing "Group" sheep (minutes)
- Number of times test sheep sniffed "Group" sheep (tally)

For each ewe the date of arena test, time of test and days from parturition was also recorded.

### 9.3.3 Maternal Behaviour

A Maternal Behaviour Score (MBS) described by O'Connor *et al*. (1985) was scored on a 5-point scale based on the distance a ewe retreated from her lambs when the shepherd tagged them (Table 9.2).

*Table 9.2 Description of the maternal behaviour score (MBS) used in this study.*

| Description of Maternal Behaviour Score (MBS) | MBS |
|---|---|
| Ewe flees as the shepherd approaches, shows no interest in lambs, does not return | 1 |
| Ewe retreats further than 10 metres, comes back to her lambs as the shepherd leaves | 2 |
| Ewe retreats to such a distance that tag identification is difficult (5-10 metres) | 3 |
| Ewe retreats but stays within 5 metres | 4 |
| Ewe stays close to the shepherd during handling of her lambs | 5 |

The following ewe behaviours were recorded immediately after tagging for a five-minute period. The time to first contact after tagging between the ewe and the lamb was recorded (ewe-lamb contact). Lambs that had no contact with their ewe five-minutes after tagging were recorded as '0' and those that did have ewe contact were recorded as '1'.

Ewe bleats were counted and categorised as low-pitch bleats (rumble calls) and high-pitch bleats. Low bleats made with the mouth closed generally occur when the ewe is in close proximity to the lamb. High ewe bleats made with the mouth open and are generally made by ewes when their lambs are separated from them (Shillito, 1972).

Ewes that moved further than 5m from the tagging site were recorded as a binary trait ('0' ewe moved away and '1' ewe stayed). The maximum distance of the ewe from any one of her lambs was roughly estimated in metres at the end of the 5-minute recording period.

For each ewe and her litter the date and time of tagging was recorded as well as the approximate age of the lambs in hours at tagging.

### 9.3.4 Lamb Behaviour

At tagging each lamb was identified by a colour spray mark and its behaviour recorded for five-minutes.

Each lamb was placed on its side on the ground immediately after tagging. The time from the end of tagging until the lamb stood was recorded in minutes. In some instances the lamb did not stand during the five minutes of observation and was recorded as '0', whereas a lamb that stood during the 5-minute post tagging period was given a score of '1'.

Individual ewe-lamb contact time was recorded (as described above). Lamb bleating while separated from its dam was recorded. Lamb bleating was recorded as a binary trait, '0' recorded for lambs that did not bleat and '1' recorded for those that did.

If the ewe moved more than 5 metres away from the tagging site, the time taken (minutes) for the lamb to follow was recorded. A lamb that failed to follow its moving dam was recorded as '0' whereas a lamb that followed was given a '1'.

Time taken for each lamb to locate the ewe's udder and to suck were also recorded. Lambs that did not perform these 'behaviours' during the 5-minutes following tagging were given a score of '0' whereas those that did were given a score of '1'. Some lambs had sucked prior to tagging, as their stomachs appeared to be full, possibly reducing the 'drive' for these lambs to suckle from their dam during the 5-minutes following tagging. Unfortunately this information was not recorded.

### 9.3.5 Statistical Analyses

The trial was set-up as a split plot design and tested for the fixed effect of pasture allowance in late pregnancy (2, 4, 6 or 8cm sward height), litter size at birth and the interaction between pasture allowance and litter size. Block and pasture allowance within block were considered random effects and specified by the RANDOM statement in PROC MIXED (SAS, 2002). Differences between litter size at birth and pasture allowance were tested using the mean square of pasture allowance within block as the error term.

Ewe liveweight, growth rate, litter weight at birth, weight of lamb weaned and litter survival were analysed using PROC MIXED (SAS, 2002). Continuously dependent ewe arena test behaviours, maternal behaviour, lamb behaviours at tagging and lamb measurements and weights were also analysed using PROC MIXED. To help decide the pathways involved in the differences in ewe and lamb performance and ewe and lamb behaviour, analyses of covariance were performed and were retained in the model if statistically significant at $P<0.05$.

The following residual maximum likelihood model (REML) was used to test the fixed effects of litter size, pasture allowance and their interaction:

$$Y_{ijkl} = \mu + B_i + P_j + L_k + PL_{jk} + BP_{ij} + \beta X_{ijkl} + e_{ijkl}$$

where $Y_{ijkl}$ = the response of the $l^{th}$ animal of the $k^{th}$ litter size of the $j^{th}$ pasture allowance in the $i^{th}$ block,

$\mu$ = general mean,

$B_i$ = random effect of the $i^{th}$ block ($i$ = Pines block or Caravan block),

$P_j$ = fixed effect of the $j^{th}$ pasture allowance ($j$=2, 4, 6 or 8cm sward height) in late pregnancy,

$L_k$ = fixed effect of the $k^{th}$ litter size at birth ($k$= twin or triplet),

$PL_{jk}$ = fixed interaction effect of pasture allowance $j$ and litter size at birth $k$,

$BP_{ij}$ = random interaction effect of pasture allowance $j$ and block $i$ *(main plot error)*,

$X_{ijk}$ = covariate tested (e.g. day of birth, ewe age, live weight, condition score),

$\beta$= regression of Y on the covariate tested (e.g. day of birth),

$e_{ijkl}$ = is the random residual effect unique to $Y_{ijkl}$.

Results are given as least square means and their standard errors. Multiple comparisons between least squares means for twin and triplet litters, sward height pasture allowance and combinations between these fixed effects were performed.

PROC CATMOD (SAS, 2002) was used to analyse categorical dependent behaviour traits (i.e. 0 = did not stand, 1 = did stand) and lamb survival at tagging and weaning (0= dead and 1 = alive). Weighted least square estimates for the fixed effects of litter size a birth (twin or triplet), pasture allowance (2, 4, 6 or 8cm sward height) and the interaction between pasture allowance and litter size were derived by Chi-squared procedures ($\chi^2$). The CONTRAST statement was used to determine if differences in fixed effects were significant at P<0.05.

The LIFETEST procedure was used to compute and plot the distribution estimate of post-tagging time behaviours for twin and triplet lambs on 2, 4, 6 and 8cm sward heights. Post-tagging behaviours such as ewe-lamb contact time, time for lamb to stand, locate the udder, suckle and follow its moving dam were analysed using PROC LIFETEST (SAS, 2002). These behaviour observations are right-censored due to the termination of the experiment (i.e. five minutes after tagging). This analysis procedure correctly uses the censored observations as well as the non-censored. The LIFETEST procedure generates a survival distribution function (SDF) and is used in this case to describe the post-tagging behaviour times. The SDF evaluated at *t* (i.e. 5 minutes) is the probability that a lamb from a specified sward height and litter size will have a 'behaviour' time exceeding *t*, that is;

$$S(t) = Pr(T>t)$$

where S(*t*) denotes the survival distribution function and T is the behaviour time of a randomly selected lamb. The cumulative distributive functions for each of the post-tagging behaviour traits are graphically plotted and are defined as 1-S(*t*), that is the probability that a behaviour time does not exceed time (*t*) (i.e. 5 minutes). To determine whether the curves plotted are homogenous across sward heights (P>0.05), PROC LIFETEST provides two rank tests (log-rank and Wilcoxon). The Wilcoxon test places more weight on early times and the log-rank test places more weight on larger times. The association between covariates and the behaviour time variable were investigated using the Wilcoxon Test and reported if significant at P<0.05. The covariate tests are pooled across sward height treatments and it is not possible to calculate the directional effect the covariate is having on the dependent variable.

Pearson correlation coefficients (*r*) were computed using SAS (PROC CORR) for continuously independent ewe and lamb behaviour and production traits and were reported if significant at P<0.10.

## 9.4 Results

### 9.4.1 Arena Test Behaviour

The ewes had been on the different feed treatments for a month at the time arena tests were performed, however pasture allowance and foetal number did not significantly affect ewe behaviour in the arena test for the majority of traits measured (Table 9.3, 9.4). Ewes grazing the 6cm pasture sward height remained closer to the person and group sheep (mean distance = 16 ± 0.92) than ewes grazing lower pasture sward heights (20 ± 0.92) (P=0.05). Ewes carrying twins tended to spend more time in Zone 4 (proportion of time: 0.42 ± 0.03) compared to ewes carrying triplets (0.35 ± 0.03) (P=0.10) and day of arena test had a significant effect on this trait (β=-0.048 ± 0.02, P<0.05). A greater proportion of ewes grazing the 8cm pasture sward height entered Zone 2 compared to ewes grazing lower pasture covers (P=0.11).

The total distance travelled by ewes was similar regardless of pasture allowance and foetal number. Whether the test was performed in the morning or afternoon significantly affected total distance travelled with ewes tested in the afternoon travelling an additional 5 metres on average.

*Table 9.3 The effect of pasture allowance and foetal number on movement within the arena (least squares mean ± standard error). Means within pasture sward height and within litter size having different letter superscripts are different (P<0.10).*

| Trait | | 2cm | 4cm | 6cm | 8cm |
|---|---|---|---|---|---|
| Total distance travelled (m) | Twin | 68 ± 9.7 | 62 ± 8.5 | 75 ± 8.1 | 71 ± 7.6 |
| | Triplet | 75 ± 10.3 | 73 ± 8.7 | 60 ± 9.4 | 58 ± 7.6 |
| Mean distance | Twin | 18 ± 1.2 $^{a\S}$ | 20 ± 1.2 $^{a*}$ | 16 ± 1.1 $^{b\S}$ | 18 ± 1.2 $^{a\S}$ |
| | Triplet | 18 ± 1.3 | 20 ± 1.2 $^{a\S}$ | 17 ± 1.3 $^{b\S}$ | 18 ± 1.2 |
| Minimum distance | Twin | 11 ± 1.3 | 12 ± 1.4 $^{a\S}$ | 9 ± 1.3 $^{b\S}$ | 9 ± 1.3 $^{b\S}$ |
| | Triplet | 11 ± 1.5 | 11 ± 1.4 | 10 ± 1.5 | 11 ± 1.4 |
| Maximum distance | Twin | 32 ± 1.02 $^{a*}$ | 30 ± 1.1 | 29 ± 1.0 $^{b*}$ | 31 ± 1.0 |
| | Triplet | 30 ± 1.2 | 30 ± 1.1 | 29 ± 1.2 | 30 ± 1.1 |
| Sheep to enter Zone 2 (proportion) | Twin | 0.17 ± 0.079 | 0.14 ± 0.073 $^{a\S}$ | 0.18 ± 0.082 | 0.36 ± 0.103 $^{b\S}$ |
| | Triplet | 0.16 ± 0.074 | 0.32 ± 0.107 | 0.18 ± 0.092 | 0.26 ± 0.101 |
| Time to Zone 2 (mins) | Twin | 2.3 ± 0.69 $^{b\S}$ | 1.1 ± 0.90 | 0.5 ± 0.69 $^{a\S}$ | 3.3 ± 0.55 $^{b*}$ |
| | Triplet | 1.4 ± 0.90 | 2.3 ± 0.59 | 2.6 ± 0.90 $^{b\S}$ | 2.5 ± 0.70 |
| Time to Zone 3 (mins) | Twin | 0.8 ± 0.24 | 1.2 ± 0.27 | 0.7 ± 0.23 | 0.8 ± 0.25 |
| | Triplet | 1.0 ± 0.27 | 0.9 ± 0.26 | 0.7 ± 0.26 | 1.2 ± 0.24 |
| Time in Zone 2 (proportion) | Twin | 0.08 ± 0.042 | 0.02 ± 0.043 | 0.10 ± 0.04 $^{1a\S}$ | 0.10 ± 0.042 |
| | Triplet | 0.05 ± 0.044 | 0.05 ± 0.044 | 0.06 ± 0.046 $^{b\S}$ | 0.08 ± 0.043 |
| Time in Zone 3 (proportion) | Twin | 0.44 ± 0.079 | 0.40 ± 0.082 | 0.55 ± 0.079 | 0.40 ± 0.081 |
| | Triplet | 0.50 ± 0.084 | 0.44 ± 0.083 | 0.54 ± 0.087 | 0.51 ± 0.082 |
| Time in Zone 4 (proportion) | Twin | 0.40 ± 0.061 | 0.53 ± 0.063 $^{a*}$ | 0.34 ± 0.061 $^{b*}$ | 0.41 ± 0.062 |
| | Triplet | 0.29 ± 0.065 | 0.43 ± 0.064 | 0.39 ± 0.069 | 0.30 ± 0.063 |
| Time in Zone 5 (proportion) | Twin | 0.06 ± 0.022 | 0.07 ± 0.023 | 0.04 ± 0.022 | 0.05 ± 0.022 |
| | Triplet | 0.07 ± 0.024 | 0.10 ± 0.023 $^{a\S}$ | 0.04 ± 0.025 $^{b\S}$ | 0.09 ± 0.023 |

No superscript = not significant (P>0.10); § P<0.10; * P<0.05.

The proportion of ewes that high-pitch bleated during the arena test significantly differed between ewes on different pasture allowances in late pregnancy (P<0.01) with a greater number of ewes grazing the 8cm sward height high-pitch bleating during the arena test than ewes on lower pasture allowances. Foetal number and the interaction between foetal number and pasture allowance were not significant across all ewes (P>0.05) (Table 9.4). Ewes on 8cm sward heights high bleated 7 ± 2.5 times compared to 2 ± 2.5 times by ewes on 4cm sward heights (P=0.10), however high-pitch bleating frequency was similar between ewes on all pasture sward heights. High pitch bleating was significantly affected by the day of the arena test (β=-0.36 ± 0.156, P<0.05).

Nearly all ewes low-pitch bleated during the arena test (Table 9.4). Condition score at pregnancy scanning had a significant effect on low-pitch bleating frequency ($\beta=3.41 \pm 1.518$, $P<0.05$) where ewes with higher body condition scores at mating low bleated more in the arena test.

Pasture allowance did significantly affect proportion of ewes that urinated during the arena test ($P<0.05$), however litter size and the interaction between the main effects were both not significant ($P>0.05$) (Table 9.4).

*Table 9.4 The effect of pasture allowance and foetal number on social behaviour within the arena (least squares mean ± standard error). Means across pasture sward heights and across litter size having different letter superscripts are different (P<0.10).*

| Trait | | 2cm | 4cm | 6cm | 8cm |
|---|---|---|---|---|---|
| Sniffed Group sheep (proportion) | Twin | 0.08 ± 0.056 | 0.09 ± 0.061 | 0.20 ± 0.08$^{a§}$ | 0.13 ± 0.070 |
| | Triplet | 0.10 ± 0.067 | 0.19 ± 0.086 | 0.06 ± 0.054$^{b§}$ | 0.14 ± 0.073 |
| Time to sniff Group | Twin | 3.2 ± 1.28 | 1.1 ± 1.28 | 1.8 ± 0.81 | 3.4 ± 1.04 |
| | Triplet | 1 ± 1.28 | 1.6 ± 1.04 | 0.9 ± 1.81 | 2.2 ± 1.04 |
| Sheep to high-pitch bleat (proportion) | Twin | 0.37 ± 0.099 | 0.18 ± 0.082$^{a*}$ | 0.44 ± 0.099 | 0.52 ± 0.104$^{b*}$ |
| | Triplet | 0.35 ± 0.107$^{a*}$ | 0.29 ± 0.099$^{a*}$ | 0.33 ± 0.111$^{a*}$ | 0.64 ± 0.103$^{b*}$ |
| High bleat tally | Twin | 6 ± 2.9 | 2 ± 2.9 | 7 ± 2.8 | 6 ± 2.9 |
| | Triplet | 8 ± 2.9$^{a§}$ | 2 ± 2.9$^{b§}$ | 2 ± 3.1$^{b§}$ | 8 ± 2.9$^{a§}$ |
| Low bleat tally | Twin | 6 ± 1.9 | 8 ± 2.0 | 7 ± 1.9 | 10 ± 1.9 |
| | Triplet | 8 ± 2.1 | 12 ± 2.0$^{a*}$ | 5 ± 2.2$^{b*}$ | 7 ± 2.0 |
| Sheep that urinated (proportion) | Twin | 0.54 ± 0.102 | 0.73 ± 0.095 | 0.64 ± 0.096 | 0.65 ± 0.099 |
| | Triplet | 0.40 ± 0.109$^{a*}$ | 0.76 ± 0.09$^{b*}$ | 0.67 ± 0.111$^{b§}$ | 0.50 ± 0.107$^{a*}$ |
| Sheep that defecated (proportion) | Twin | 0.25 ± 0.085 | 0.32 ± 0.099 | 0.12 ± 0.065$^{a*}$ | 0.26 ± 0.092 |
| | Triplet | 0.20 ± 0.089 | 0.29 ± 0.098 | 0.44 ± 0.11$^{b*}$ | 0.23 ± 0.089 |
| Defecation tally | Twin | 0.3 ± 0.13 | 0.3 ± 0.14 | 0.1 ± 0.13$^{a*}$ | 0.3 ± 0.13 |
| | Triplet | 0.2 ± 0.14$^{a§}$ | 0.3 ± 0.14 | 0.6 ± 0.14$^{b*}$ | 0.2 ± 0.14$^{a*}$ |

No superscript = not significant (P>0.10); § P<0.10; * P<0.05.

## 9.4.2 Maternal Behaviour

Maternal behaviour score was similar between ewes on differing pasture allowances (Figure 9.3, Table 9.5). Ewe high-pitch bleating frequency had a significant effect on MBS ($\beta=-0.08 \pm 0.009$, $P<0.0001$), the ewes with lower MBS high bleated more times in the five minute observation period following tagging (Table 9.8). A greater proportion of ewes grazing the 8cm sward height stayed with their litter after tagging compared with ewes on the 2cm pasture sward height ($P=0.07$) (Figure 9.4, Table 9.5).

Ewes with triplet litters on the 2cm pasture sward height were farthest from their litter at the end of the five minute observation period compared to ewes on higher pasture allowances and ewes with twin litters on the 2cm sward height (Table 9.5).

*Figure 9.3 The effect of pasture allowance on MBS (least squares mean ± standard error).*

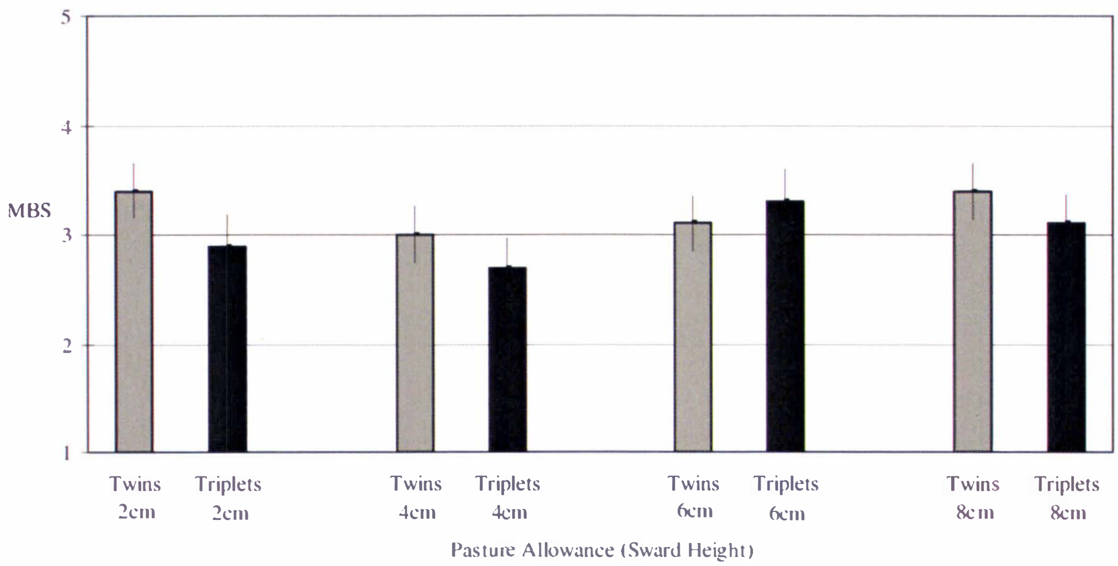
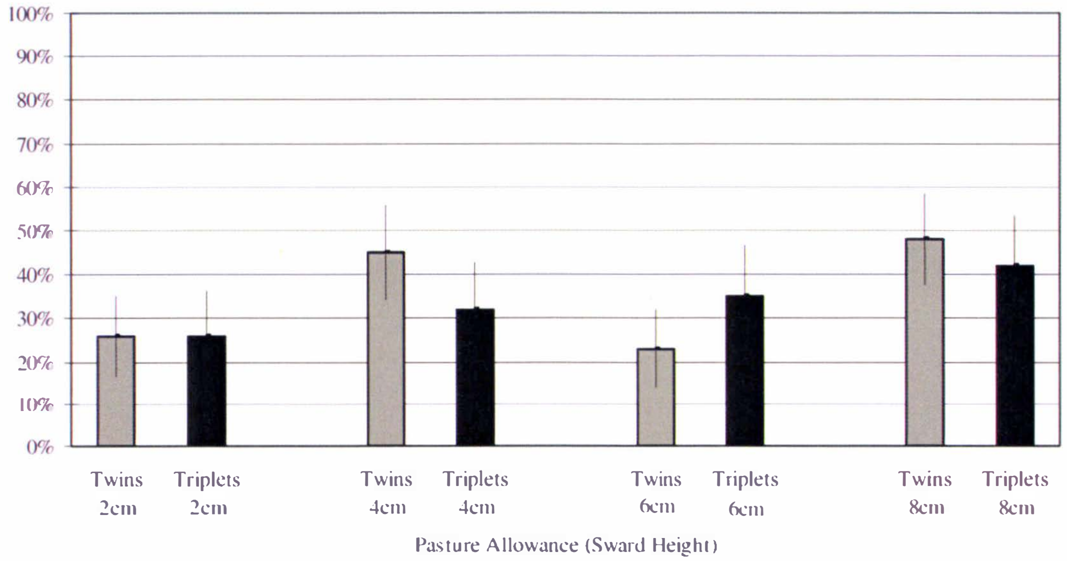



*Figure 9.4 The effect of pasture allowance on proportion of ewes that stayed at the tagging site after tagging (least squares mean ± standard error).*




Ewes with triplet litters high bleated significantly more post-tagging (8 ± 1.15 bleats) compared to ewes with twin litters (5 ± 1.06 bleats) ($P<0.05$) (Table 9.5). High pitch bleating frequency was similar for ewes grazing all pasture sward heights ($P>0.05$) (Table 9.5) and there was no significant interaction between feeding level up to tagging and litter size at birth (P>0.05). The proportion of time spent in Zone 5 during the arena test had a significant effect on high bleating frequency after tagging ($\beta$=13.17 ± 6.211, P<0.05; $r$=0.20, P<0.05) where ewes that spent longer in Zone 5 in the arena test high bleated more after tagging. Litter size at birth tended to influence ewe low bleat frequency after tagging (P=0.14).

*Table 9.5 The effect of pasture allowance and litter size on MBS and ewe tagging behaviour (least squares mean ± standard error). Means across pasture sward height and across litter size having different letter superscripts are different (P<0.10).*

| Trait | | 2cm | 4cm | 6cm | 8cm |
|---|---|---|---|---|---|
| MBS | Twin | 3.4 ± 0.25 | 3.0 ± 0.26 | 3.1 ± 0.25 | 3.4 ± 0.26 |
| | Triplet | 2.9 ± 0.29 | 2.7 ± 0.27 | 3.3 ± 0.29 | 3.1 ± 0.26 |
| Ewes that stayed (proportion) | Twin | 0.26 ± 0.092 [a§] | 0.45 ± 0.106 | 0.23 ± 0.089 | 0.48 ± 0.104 [b§] |
| | Triplet | 0.26 ± 0.101 | 0.32 ± 0.107 | 0.35 ± 0.116 | 0.42 ± 0.113 |
| Ewe high bleats | Twin | 4 ± 2.1 [a*] | 6 ± 2.1 | 7 ± 2.1 | 2 ± 2.2 [a§] |
| | Triplet | 11 ± 2.4 [b*] | 6 ± 2.3 | 7 ± 2.3 | 7 ± 2.2 [b§] |
| Ewe low bleats | Twin | 2.6 ± 0.50 [a*] | 1.4 ± 0.51 [b§] | 1.2 ± 0.49 [b*] | 1.5 ± 0.53 |
| | Triplet | 0.7 ± 0.61 [b*] | 1.7 ± 0.59 | 0.8 ± 0.59 | 1.1 ± 0.58 |
| Maximum distance after tagging (m) | Twin | 5 ± 3.6 [a*] | 3 ± 3.6 | 6 ± 3.6 | 3 ± 3.7 |
| | Triplet | 16 ± 4.5 [b*] | 0 ± 4.6 [a*] | 1 ± 4.2 [a*] | 5 ± 3.8 [a§] |

No superscript = not significant (P>0.10); § P<0.10; * P<0.05.

## 9.4.3 Dam Performance

Ewes grazing the 2cm pasture sward height were significantly lighter after tagging compared to ewes on higher pasture allowances (P<0.01). Ewes with twin and triplet litters were similar weights after tagging (P>0.05) (Table 9.6). Ewe liveweight after tagging was significantly affected by body condition score at pregnancy scanning ($\beta$=4.75 ± 1.33, P<0.001). Ewe age affected liveweight after tagging ($\beta$=5.19 ± 1.231, P<0.0001), where mixed age ewes were heavier (61 ± 0.87 kg) than 2 year old ewes (56 ± 0.93kg). Litter weight at birth affected ewe liveweight after tagging ($\beta$=1.15 ± 0.374, P<0.01) where heavier ewes gave birth to heavier litters.

Pasture allowance up to weaning (4cm versus 8cm sward height) had a significant effect on ewe weight at weaning ($\beta$=0.52 ± 0.255, P<0.05). Ewes on the higher feed allowance were 2kg heavier (4cm sward height 62 ± 0.73 kg; 8cm sward height 64 ± 0.75kg). Ewes grazing the 6cm pasture sward height in late pregnancy and with triplet litters at birth, were significantly heavier at weaning than ewes with triplet litters grazing the 4cm pasture allowance (P<0.05) (Table 9.6). Litter weight at birth (β=0.67 ± 0.339, P<0.05), ewe age (β=4.72 ± 1.149, P<0.0001) and condition score at pregnancy scanning (β=4.01 ± 1.338, P<0.01) all had a significant effect on ewe weight at weaning.

Ewes on the 2cm pasture allowance in late pregnancy gained significantly more weight from lamb tagging to weaning than ewes on higher pasture allowances over the same period (Table 9.6). Pasture allowance from tagging to weaning also had a significant effect on ewe weight gain (β=9.19 ± 2.924, P<0.01). Ewes on the 8cm pasture allowance gained twice as much weight (68 ± 13.2 g/day) than ewes on the 4cm pasture allowance (32 ± 13.5 g/day).

*Table 9.6 The effect of pasture allowance and litter size at birth on ewe liveweight and growth (least squares mean ± standard error). Means within pasture sward height and within litter size having different letter superscripts are different (P<0.10).*

| Trait | | 2cm | 4cm | 6cm | 8cm |
|---|---|---|---|---|---|
| Ewe weight at tagging (kg) | Twin | 52 ± 1.8 $^{a*}$ | 63 ± 1.6 $^{b*}$ | 60 ± 1.6 $^{b*}$ | 63 ± 1.6 $^{b*}$ |
| | Triplet | 50 ± 1.8 $^{a*}$ | 60 ± 1.8 $^{b*}$ | 62 ± 1.8 $^{b*}$ | 60 ± 1.8 $^{b*}$ |
| Ewe weight at weaning (kg) | Twin | 59 ± 1.6 $^{a*}$ | 65 ± 1.4 $^{b*}$ | 65 ± 1.3 $^{b*}$ | 64 ± 1.4 $^{b*}$ |
| | Triplet | 60 ± 1.6 $^{a*}$ | 62 ± 1.5 | 66 ± 1.5 $^{b*}$ | 64 ± 1.5 $^{b§}$ |
| Ewe weight gain (grams/day) | Twin | 106 ± 20.7 $^{a*}$ | 38 ± 18.1 $^{b*}$ | 53 ± 18.2 $^{b*}$ | 23 ± 18.5 $^{b*}$ |
| | Triplet | 120 ± 23.1 $^{a*}$ | 14 ± 19.3 $^{b*}$ | 17 ± 20.2 $^{a*}$ | 29 ± 19.3 $^{a*}$ |

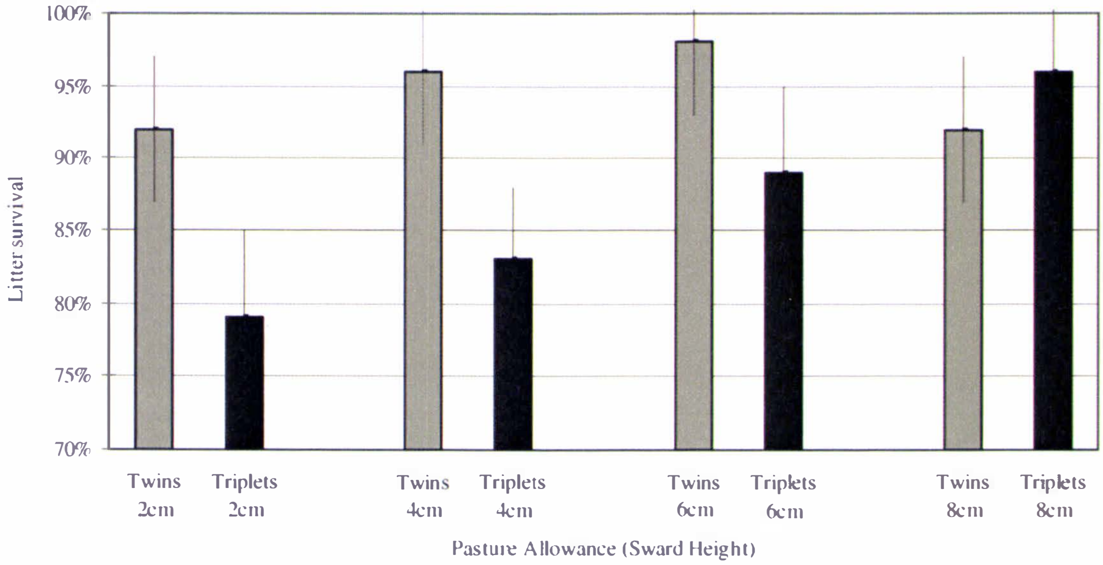
No superscript = not significant (P>0.10); § P<0.10; * P<0.05.

Ewe lamb rearing performance is presented in Table 9.7. Litter weight was significantly lighter for ewes grazing the 2cm sward height (9.2 ± 0.30 kg) in late pregnancy compared to ewes grazing the 8cm (10.6 ± 0.30 kg) sward height (P<0.05). Triplet litters weighed significantly more at tagging than twin litters regardless of pasture allowance in late pregnancy (twins 9.2 ± 0.22kg; triplets 10.8 ± 0.23kg, P<0.0001).

Pasture allowance in late pregnancy and litter size at birth did not significantly affect weight of lamb weaned (P>0.05). Dam age and pasture allowance from tagging to weaning also did not affect weight of lamb weaned (P>0.05). Days from tagging to weaning significantly influenced weight of lamb weaned (β=0.86 ± 0.278, P<0.01).

Twin litter survival from birth to tagging was similar regardless of pasture allowance in late pregnancy (Figure 9.5, Table 9.7). However triplet litter survival was significantly greater for ewes grazing the 8cm pasture sward height compared to ewes on the 2cm and 4cm sward heights (Figure 9.5, Table 9.7). Overall triplet litter survival (86% ± 0.04) was lower than twin litter survival (94% ± 0.04) to tagging ($P<0.05$).

*Figure 9.5 The effect of litter size at birth and pasture allowance late pregnancy on ewe litter survival from birth to tagging (least squares mean ± standard error).*




Pasture allowance in late pregnancy and from tagging to weaning did not have a significant effect on litter survival from tagging to weaning ($P>0.05$). Litter survival from tagging to weaning was significantly higher for twin (90% ± 0.03) than triplet litters (79% ± 0.03) ($P<0.05$).

Pasture allowance in late pregnancy did not significantly affect overall litter survival from birth to weaning ($P>0.05$) (Table 9.7). Litter survival from birth to weaning was affected by the time taken to enter Zone 2 in the arena test ($\beta=0.05 \pm 0.029$, $P=0.11$). Twin litter survival to weaning was significantly higher than triplet litter survival (twins 86% ± 0.03; triplets 68% ± 0.03) ($P<0.001$).

Ewes giving birth to triplet litters on the highest pasture allowance had significantly larger litters at tagging than ewes giving birth to twin litters ($P<0.05$). Litter size at weaning was similar despite litter size at birth and feeding level in late pregnancy (Table 9.7).

*Table 9.7 The effect of pasture allowance and litter size on ewe lamb rearing performance (least squares mean ± standard error). Means across pasture sward height and across litter size having different letter superscripts are different (P<0.10).*

| Trait | | 2cm | 4cm | 6cm | 8cm |
|---|---|---|---|---|---|
| Litter size at tagging | Twin | 1.8 ± 0.13 | 1.9 ± 0.14 | 2.0 ± 0.13 | 1.8 ± 0.13 |
| | Triplet | 2.4 ± 0.14 $^{a}$* | 2.5 ± 0.14 $^{a}$* | 2.7 ± 0.15 | 2.9 ± 0.14 $^{b}$* |
| Litter size at weaning | Twin | 1.7 ± 0.15 | 1.8 ± 0.15 | 1.8 ± 0.14 | 1.7 ± 0.15 $^{a}$* |
| | Triplet | 1.9 ± 0.16 | 2.2 ± 0.16 | 2.1 ± 0.17 | 2.1 ± 0.15 $^{b}$* |
| Litter survival birth to tagging | Twin | 0.92 ± 0.052 $^{a}$* | 0.96 ± 0.054 $^{a}$* | 0.98 ± 0.052 | 0.92 ± 0.052 |
| | Triplet | 0.79 ± 0.056 $^{b}$* | 0.83 ± 0.055 $^{b}$* | 0.89 ± 0.058 | 0.96 ± 0.054 $^{a}$* |
| Litter survival tagging to weaning | Twin | 0.88 ± 0.056 | 0.95 ± 0.058 | 0.90 ± 0.055 | 0.85 ± 0.056 |
| | Triplet | 0.78 ± 0.061 | 0.89 ± 0.059 | 0.77 ± 0.065 | 0.74 ± 0.058 |
| Litter survival birth to weaning | Twin | 0.83 ± 0.057 $^{a}$* | 0.91 ± 0.06 $^{a}$* | 0.88 ± 0.056 $^{a}$* | 0.83 ± 0.057 |
| | Triplet | 0.62 ± 0.06 $^{b}$* | 0.73 ± 0.06 $^{b}$* | 0.69 ± 0.07 $^{b}$* | 0.70 ± 0.06 |
| Litter weight at birth (kg) | Twin | 8.6 ± 0.36 $^{a}$* | 9.2 ± 0.37 | 9.4 ± 0.35 | 9.7 ± 0.36 $^{b}$* |
| | Triplet | 9.7 ± 0.38 $^{b}$* | 11.5 ± 0.37 $^{a}$* | 10.5 ± 0.39 $^{b}$* | 11.6 ± 0.36 $^{a}$* |
| Weight of lamb weaned (kg) | Twin | 44 ± 3.7 | 49 ± 3.8 | 51 ± 3.6 | 47 ± 3.8 |
| | Triplet | 43 ± 3.9 $^{a}$* | 55 ± 3.9 $^{b}$* | 50 ± 4.2 | 49 ± 3.8 |

No superscript = not significant (P>0.10); § P<0.10; * P<0.05.

Preliminary analyses did not identify any arena and maternal behaviour effects on lamb rearing performance. Therefore correlations were performed to determine if there were any relationships between ewe behaviour and lamb rearing performance.

There were some significant correlations between ewe behaviours and lamb rearing performance (Table 9.8). The arena behaviours which showed the most promise as indicators for lamb rearing performance, were time to enter Zone 2 and time to sniff Group sheep, with the ewes having a lower flocking tendency having higher litter survival rates.

MBS was not significantly correlated with lamb rearing performance (Table 9.8). The ewe behaviours observed after tagging which showed the most promise as indicators for litter survival to weaning were high bleating frequency and distance of litter from ewe five minutes after tagging (Table 9.8). Ewes that high pitch bleated fewer times and remained close to all of the lambs in their litter had higher litter survival rates.

There were some litter size specific correlations; ewes that took longer to enter Zone 2 and had greater maximum distances in the arena test had heavier triplet litters at tagging (*r*=0.43 and *r*=0.18 respectively; P<0.10) and ewes with twin litters that took longer to sniff the group sheep in the arena test had higher MBS at tagging (*r*=0.56, P<0.10). Ewes that had greater low bleat frequencies in the arena test had slightly higher triplet litter weights at birth and at weaning (*r*=0.18 and 0.19 respectively; P<0.10).

*Table 9.8 Correlations between ewe behaviour and performance traits across all sheep regardless of litter size at birth.*

| | MBS | Litter weight at birth | Weight of lamb weaned | Litter survival from: birth to weaning | birth to tagging | tagging to weaning |
|---|---|---|---|---|---|---|
| MBS | | ns | ns | ns | ns | ns |
| High bleats after tagging | -0.54 **** | ns | ns | -0.13 § | ns | ns |
| Low bleats after tagging | ns | ns | ns | ns | ns | ns |
| Maximum distance from lamb after tagging | -0.30 *** | ns | ns | -0.12 (P=0.13) | ns | -0.18 * |
| Arena distance travelled | ns | ns | ns | ns | ns | ns |
| Arena mean distance | ns | ns | ns | ns | ns | ns |
| Arena minimum distance | ns | ns | ns | ns | ns | ns |
| Arena maximum distance | ns | ns | ns | ns | ns | ns |
| Time to Arena Zone 2 | ns | ns | ns | 0.28 § | 0.24 (P=0.15) | ns |
| Time to Arena Zone 3 | ns | ns | ns | ns | ns | ns |
| Time spent in Arena Zone 2 | ns | ns | ns | ns | ns | ns |
| Time spent in Arena Zone 3 | ns | ns | ns | ns | ns | ns |
| Time spent in Arena Zone 4 | ns | ns | ns | ns | ns | ns |
| Time spent in Arena Zone 5 | ns | 0.12 § | ns | ns | ns | ns |
| Time to sniff Group sheep | ns | ns | ns | ns | 0.35 (P=0.12) | ns |
| Arena high bleats | ns | 0.14 § | ns | ns | ns | ns |
| Arena low bleats | ns | ns | ns | ns | ns | ns |

ns= not significant (P>0.10); § P<0.10; * P<0.05 ** P<0.10, ***P<0.001 and ****P<0.0001.

## 9.4.4 Lamb Behaviour

Lamb behaviours were recorded for individual lambs within a litter. Pasture sward height allowance up to and at lambing had a significant effect on a number of lamb behaviours observed in the five-minute observation period immediately after tagging (Table 9.9).

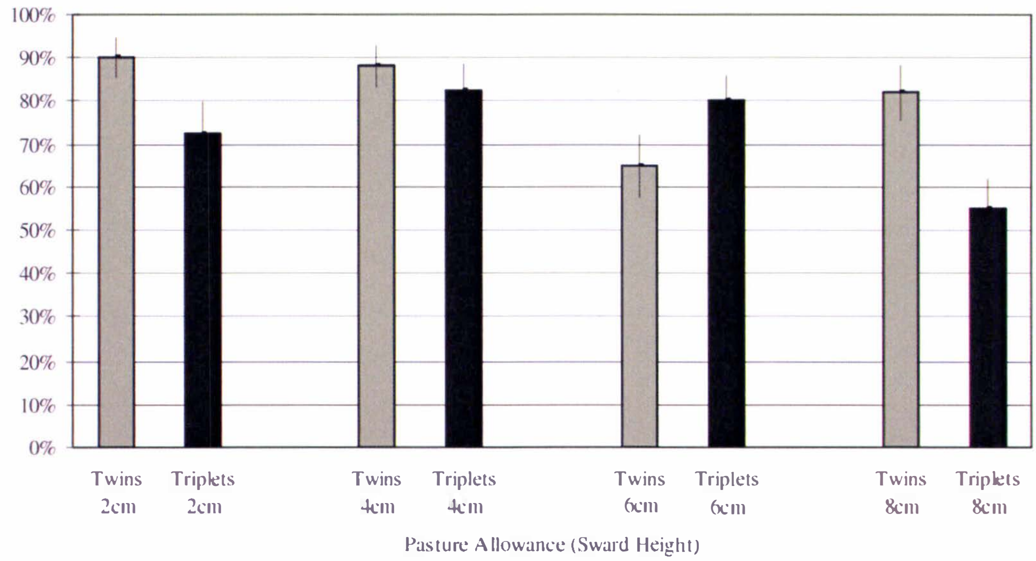
*Table 9.9 The effect of pasture allowance and litter size on lamb behaviour in the five-minute observation period immediately following tagging (weighted least squares mean ± standard error). Proportions across pasture sward height having different letter superscripts are different (P<0.10).*

| Trait | | 2cm | 4cm | 6cm | 8cm |
|---|---|---|---|---|---|
| Lambs that bleated before ewe contact | Twin | 0.90 ± 0.05 | 0.88 ± 0.05 [a]* | 0.65 ± 0.07 [b]* | 0.82 ± 0.06 |
| | Triplet | 0.73 ± 0.07 [a]* | 0.83 ± 0.06 | 0.80 ± 0.06 | 0.55 ± 0.07 [b]* |
| Lambs to make ewe contact | Twin | 0.91 ± 0.04 | 0.93 ± 0.04 | 0.89 ± 0.05 | 0.93 ± 0.03 |
| | Triplet | 0.63 ± 0.07 [a]* | 0.69 ± 0.06 | 0.85 ± 0.05 [b]§ | 0.87 ± 0.05 [b]* |
| Lambs that stood | Twin | 0.91 ± 0.04 | 0.91 ± 0.04 | 0.89 ± 0.05 | 0.82 ± 0.06 |
| | Triplet | 0.63 ± 0.07 [a]§ | 0.67 ± 0.06 | 0.85 ± 0.05 [b]§ | 0.81 ± 0.05 |
| Lambs that located ewe udder | Twin | 0.72 ± 0.07 | 0.66 ± 0.07 | 0.64 ± 0.07 | 0.69 ± 0.07 |
| | Triplet | 0.35 ± 0.07 | 0.35 ± 0.06 [a]§ | 0.62 ± 0.07 [b]§ | 0.51 ± 0.07 |
| Lambs that suck from ewe | Twin | 0.37 ± 0.07 | 0.27 ± 0.07 | 0.27 ± 0.07 | 0.29 ± 0.07 |
| | Triplet | 0.20 ± 0.06 | 0.18 ± 0.05 | 0.19 ± 0.05 | 0.16 ± 0.05 |
| Lambs that followed moving ewe | Twin | 0.77 ± 0.07 | 0.88 ± 0.07 | 0.86 ± 0.06 | 0.61 ± 0.10 |
| | Triplet | 0.49 ± 0.08 | 0.43 ± 0.08 | 0.65 ± 0.08 | 0.75 ± 0.08 |

No superscript = not significant (P>0.10); § P<0.10; * P<0.05.

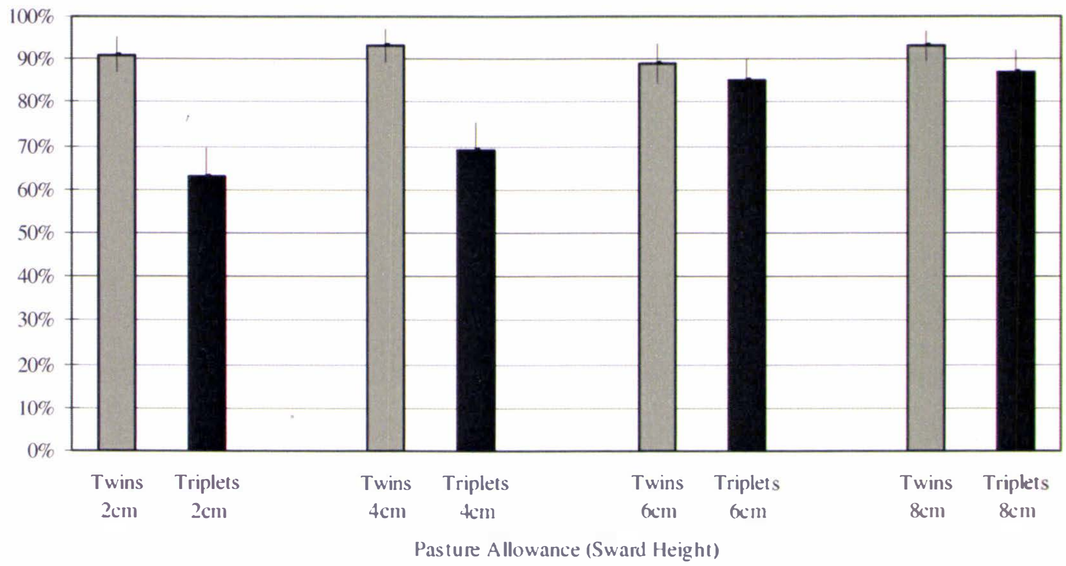
The proportion of lambs bleating after tagging before ewe contact was significantly affected by pasture allowance (P<0.05), litter size at birth (P<0.05) and the interaction between pasture allowance and litter size (P<0.01). Triplet lambs born to ewes grazing the 8cm pasture sward height were less likely to bleat before ewe contact than lambs born to ewes grazing lower pasture covers (Figure 9.6, Table 9.9).

*Figure 9.6 The effect of pasture allowance on proportion of lambs to bleat before ewe contact after tagging (standard errors included).*



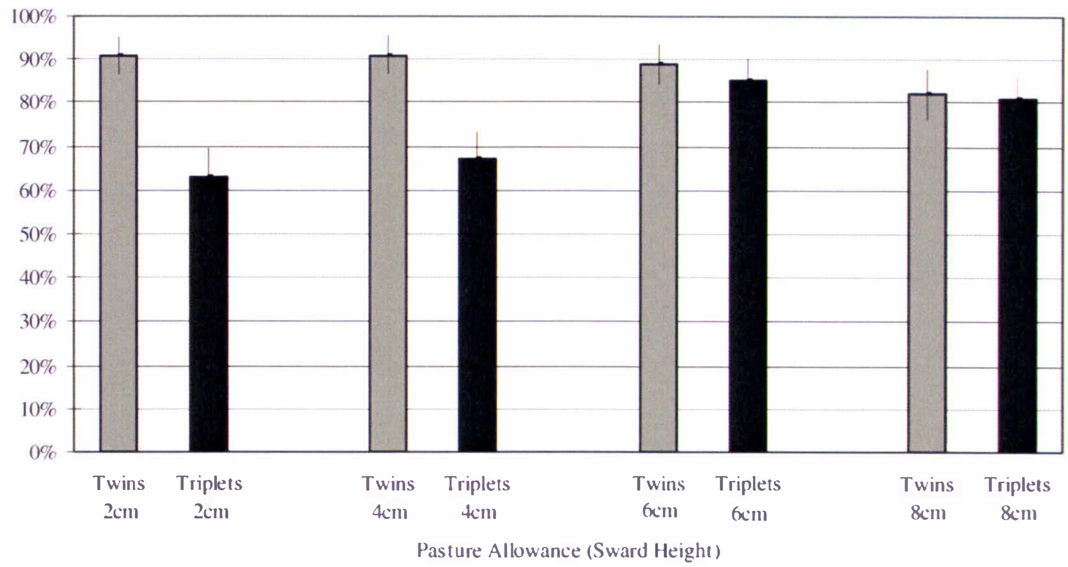
Ewe-lamb contact was significantly affected by pasture allowance (P<0.05), ewe litter size at birth (P<0.001) and the interaction between pasture allowance and litter size (P<0.001) (Table 9.9, Figure 9.7). The proportion of ewes to make contact with twin lambs was similar regardless of pasture allowance. However fewer ewes with triplet litters made lamb contact if grazing lower pasture sward heights.

*Figure 9.7 The effect of pasture allowance on proportion of ewes to make lamb contact after tagging (standard errors included).*



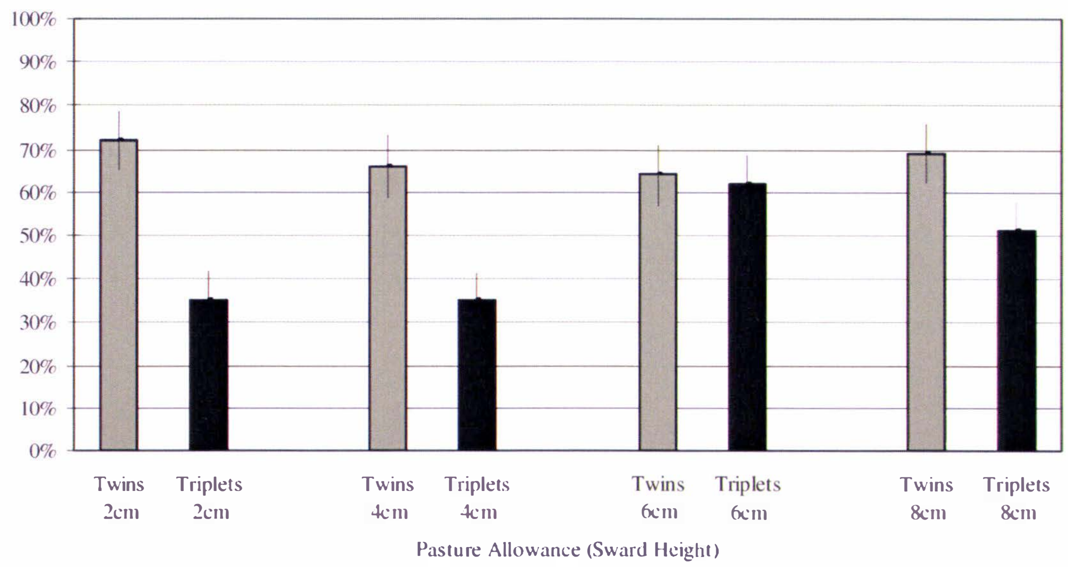

The proportion of lambs that stood in the 5-minute observation period immediately following tagging were not significantly affected by pasture allowance (P>0.05), however this lamb behaviour was affected by lamb litter size at birth (P<0.001) and the interaction between pasture allowance and litter size (P<0.05). Fewer triplet born lambs stood at lower pasture sward heights and were significantly different to the proportion of twin lambs that stood (P<0.05) (Table 9.9, Figure 9.8).

*Figure 9.8 The effect of pasture allowance on proportion of lambs to stand in the five-minute observation period immediately after tagging (standard errors included).*



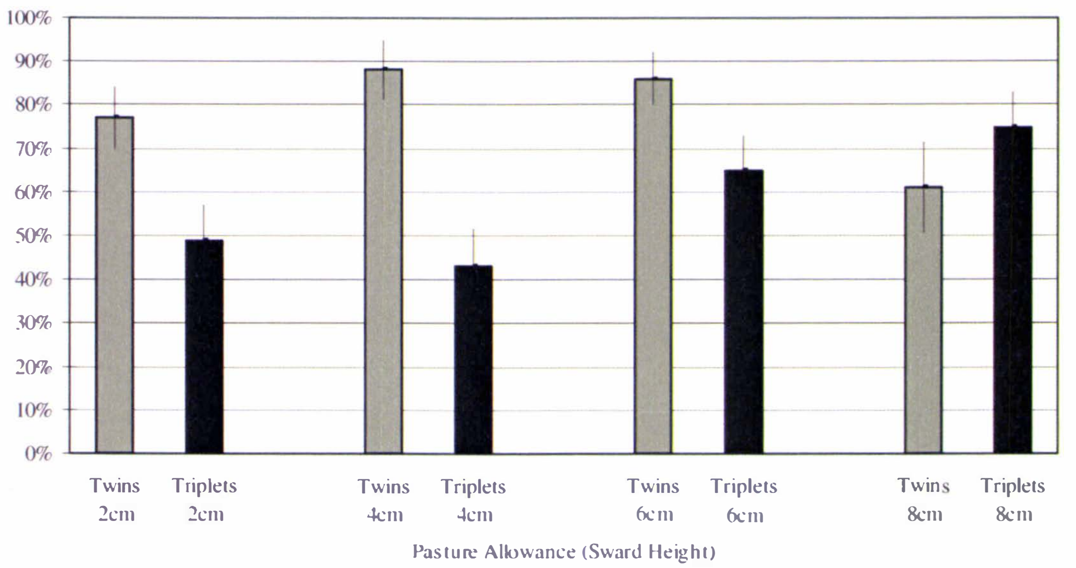

A lamb's ability to locate its dam's udder after tagging was significantly affected by the interaction between pasture allowance and litter size ($P<0.05$). The effect of litter size was significant ($P<0.0001$) and pasture allowance was not ($P>0.05$). As pasture allowance increased the number of triplet lambs to locate their dam's udder increased (Figure 9.9, Table 9.9). Fewer triplet lambs sucked from their dam after tagging compared to twin lambs ($P<0.01$). Pasture allowance did not significantly effect the proportion of lambs to suck from their dams ($P>0.05$) (Table 9.9).

*Figure 9.9 The effect of pasture allowance on the proportion of lambs to locate their dam's udder in the five-minute observation period immediately after tagging (standard errors included).*



The proportion of lambs to follow their moving dam was significantly affected by litter size and the interaction between the main effects (P<0.001) (Table 9.9, Figure 9.10). The proportion of triplet lambs that followed their moving dam increased as pasture allowance increased (P<0.01). Fewer triplet born lambs followed their moving dam compared to twin born lambs at all sward heights except the highest (8cm sward height twins and triplets similar).

*Figure 9.10 The effect of pasture allowance on the proportion of lambs to follow their moving dam after tagging (standard errors included).*




Times related to behaviour after tagging were analysed using the Lifetest procedure and the comparison of cumulative distributions for 2, 4, 6 and 8cm sward heights are reported separately for twins and triplets in Table 9.10. Triplet lamb behaviour differed significantly across sward heights for the majority of time related traits, whereas twin behaviour was similar (Table 9.10). Lamb birth weight was not significantly related to twin and triplet lamb post-tagging behaviour times (P>0.05).

Approximately eighty percent of all twin lambs made ewe contact in one minute and did not differ significantly across pasture sward heights (Figure 9.7a, Table 9.10). Approximately 50% of triplet lambs made ewe contact in one minute and this did differ across pasture sward height (P<0.05) (Figure 9.7b, Table 9.10). MBS, high ewe bleats and day of tagging were all related to ewe-lamb contact time for twin (P<0.001) and triplet lambs (P<0.001). Ewe-lamb contact time after tagging was quicker if the ewe had a higher MBS and high bleated fewer times.

Forty percent of the triplet lambs on the 2cm sward height stood in one minute compared with 65% on the 8cm sward height (Figure 9.8b), whereas 80% of twin lambs born on the 2cm pasture sward height had stood by the same time (Figure 9.8a). Factors significantly affecting the time for twin and triplet lambs to stand included: MBS, ewe high bleat frequency, whether the lamb was vocal or not and lamb age at tagging (all P<0.01). Younger lambs (determined by the number of hours between birth and tagging) took longer to stand (*r*=-0.19; P<0.001) and the longer the lamb took to stand the more its ewe high bleated (*r*=0.48; P<0.0001). Lambs that were quick to stand bleated more.

Within 2 minutes approximately 40% of all twin lambs across all pasture sward heights had located their ewe's udder (Figure 9.9a), whereas only 20% of all triplet lambs had located the udder (Figure 9.9b). Ewe high bleat frequency was related to the time taken for the udder to be located by the lamb after tagging (P<0.01). The longer the lamb took to locate the ewe's udder the more the ewe high bleated (Table 9.12).

The distribution curves for twin lambs following their moving dam were different over time (P<0.05) (Figure 9.10a, Table 9.10). Ewe low bleating frequency was related to follow time for twin lambs (P<0.05) and not for triplets (P>0.05). There was no significant correlation between ewe low bleat frequency and time for lamb to follow its moving dam.

Approximately 30% of all twin lambs had sucked from their dam during the 5 minutes of observation (Figure 9.11a), whereas less than 20% of triplet lambs had successfully sucked (Figure 9.11b).

*Figure 9.7a and 9.7b. The effect of pasture allowance on the proportion of lambs to have ewe contact within five minutes from tagging. Graphs of estimated 'behaviour' functions for twin lambs (Figure 9.7a) and for triplets (Figure 9.7b).*

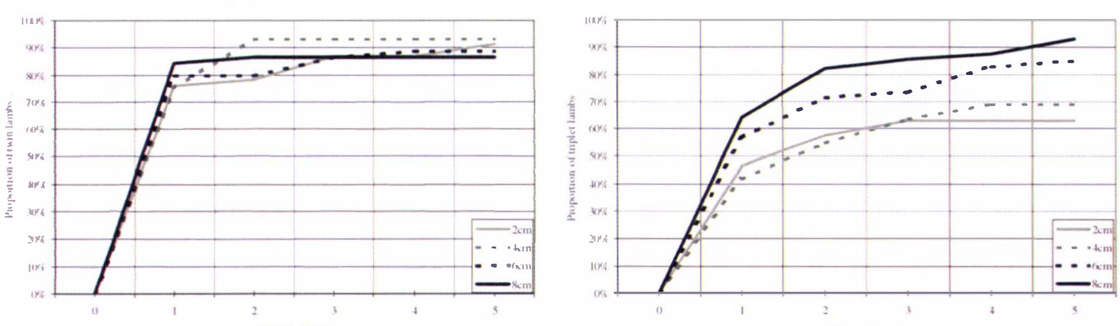


*Figure 9.8a and 9.8b. The effect of pasture allowance on the proportion of lambs to stand within five minutes from tagging. Graphs of estimated 'behaviour' functions for twins (Figure 9.8a) and for triplets (Figure 9.8b).*

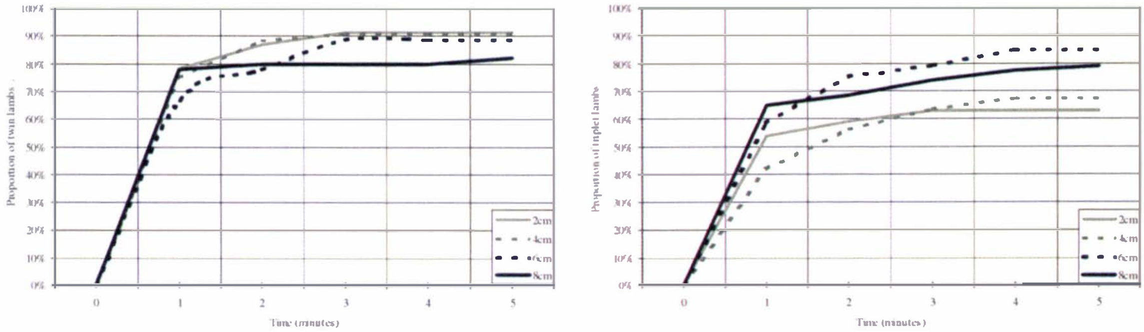



*Figure 9.9a and 9.9b. The effect of pasture allowance on the proportion of lambs to locate their dam's udder within five minutes from tagging. Graphs of estimated 'behaviour' functions for twin lambs (Figure 9.9a) and for triplets (Figure 9.9b).*

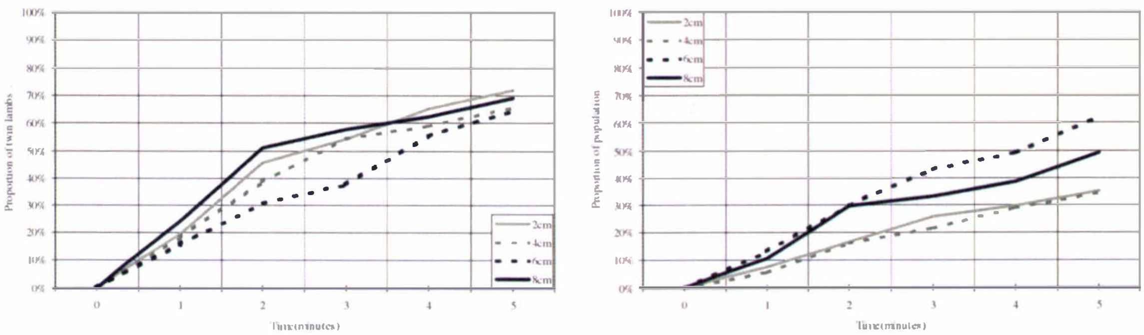



*Figure 9.10a and 9.10b. The effect of pasture allowance on the proportion of lambs to follow their moving dam within five minutes from tagging. Graphs of estimated 'behaviour' functions for twin lambs (Figure 9.10a) and for triplets (Figure 9.10b).*

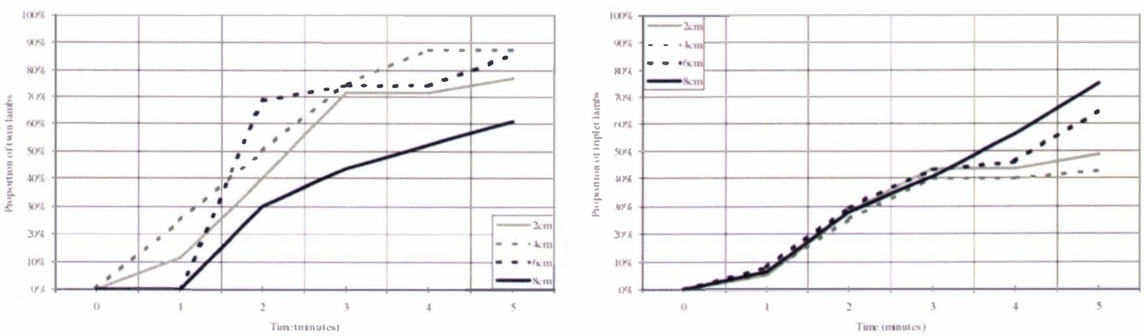



*Figure 9.11a and 9.11b. The effect of pasture allowance on the proportion of lambs to suckle within five minutes from tagging. Graphs of estimated behaviour functions for twin lambs (Figure 9.11a) and for triplets (Figure 9.11b).*

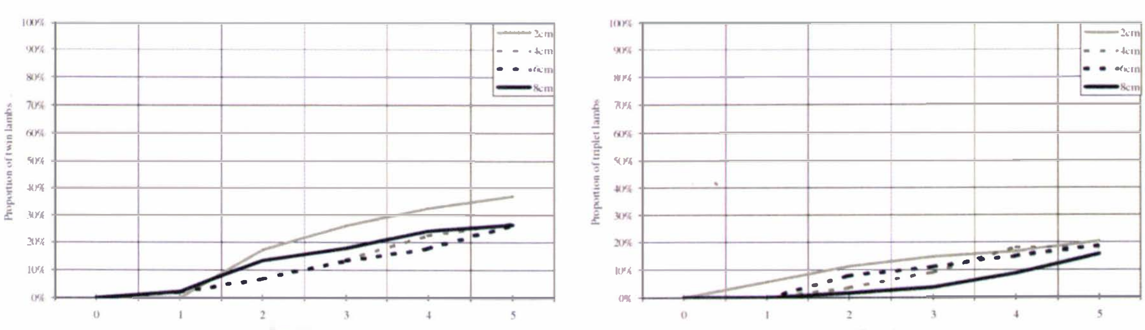


*Table 9.10 The effect of pasture allowance (sward height) on lamb behaviour times after tagging for twins and triplets (Wilcoxon mean ± standard error). Times are presented as minutes.*

| Trait | Litter size | 2cm | 4cm | 6cm | 8cm | P Wilcoxon | P Log-Rank |
|---|---|---|---|---|---|---|---|
| Ewe-lamb contact | Twin Figure 9.7a | 0.7 ± 0.16 | 0.6 ± 0.07 | 0.6 ± 0.12 | 0.4 ± 0.04 | ns | ns |
| | Triplet Figure 9.7b | 0.6 ± 0.12 | 1.2 ± 0.19 | 1.0 ± 0.18 | 0.9 ± 0.16 | * | *** |
| Lamb to stand | Twin Figure 9.8a | 0.5 ± 0.09 | 0.5 ± 0.09 | 0.7 ± 0.13 | 0.4 ± 0.11 | ns | ns |
| | Triplet Figure 9.8b | 0.6 ± 0.11 | 1 ± 0.16 | 0.8 ± 0.14 | 0.9 ± 0.18 | § | * |
| Lamb locate udder | Twin Figure 9.9a | 1.9 ± 0.22 | 1.9 ± 0.24 | 2.4 ± 0.27 | 1.7 ± 0.23 | ns | ns |
| | Triplet Figure 9.9b | 2.3 ± 0.29 | 2.4 ± 0.30 | 2.3 ± 0.25 | 2.3 ± 0.28 | ** | ** |
| Follow dam | Twin Figure 9.10a | 2.0 ± 0.20 | 1.8 ± 0.20 | 1.9 ± 0.21 | 2.4 ± 0.33 | * | * |
| | Triplet Figure 9.10b | 2.2 ± 0.22 | 1.8 ± 0.24 | 2.6 ± 0.29 | 2.8 ± 0.27 | ns | § |
| Lamb to suckle | Twin Figure 9.11a | 2.5 ± 0.24 | 2.8 ± 0.33 | 3.0 ± 0.39 | 2.5 ± 0.39 | ns | ns |
| | Triplet Figure 9.11b | 2.2 ± 0.42 | 2.8 ± 0.34 | 2.8 ± 0.45 | 3.7 ± 0.37 | ns | ns |

ns=not significant at P<0.10, § P<0.10, * P<0.05, ** P<0.01, *** P<0.001 and **** P<0.0001

Lambs that bleated after tagging were closer to their dam (1.2 ± 0.85m) at the end of the five-minute observation period than lambs that did not bleat (6.3 ± 1.44m) ($\beta$=-5.11 ± 1.536, P<0.01). Other factors significantly affecting lamb-dam distance 5 minutes after tagging included ewe high bleat frequency ($\beta$=0.61 ± 0.078, P<0.0001), time of day lambs were ear-tagged ($\beta$=1.11 ± 0.44, P<0.01) and lamb age at tagging ($\beta$=0.24 ± 0.097, P<0.05). Pasture allowance did not significantly affect twin lamb distance from its dam 5 minutes after tagging (twins 4.7 ± 1.12m). However triplet lambs born to ewes on the 2cm pasture sward height were further from their dam (8 ± 2.1m) than triplets born to ewes allocated higher pasture allowances (triplets 2.9 ± 1.08m) (P<0.05).

## 9.4.5 Lamb Performance

Pasture allowance in late pregnancy did not significantly affect lamb birth weight (Table 9.11). The interaction between pasture allowance and litter size at birth significantly affected lamb birth weight (P<0.05). Individual twin lambs (4.5 ± 0.06kg) were heavier than triplet lambs (3.7 ± 0.06kg) (P<0.0001).

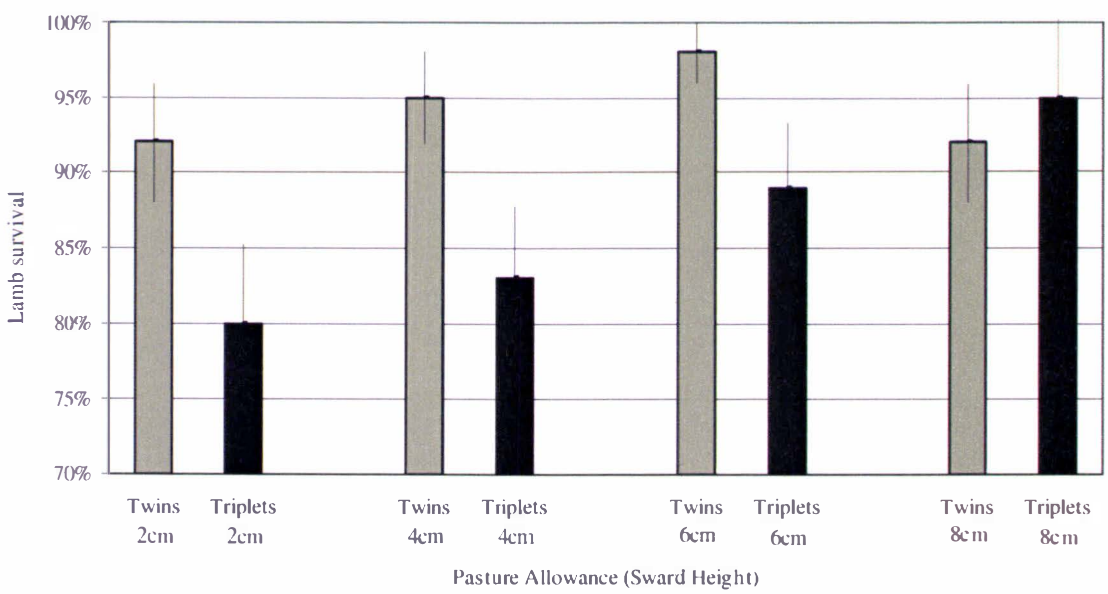
*Table 9.11 The effect of pasture allowance and litter size on individual lamb performance (least squares mean ± standard error). Means across pasture sward height having different letter superscripts are different (P<0.10).*

| Trait | | 2cm | 4cm | 6cm | 8cm |
|---|---|---|---|---|---|
| Birth weight (kg) | Twin | 4.5 ± 0.13 | 4.4 ± 0.12 $^{a\S}$ | 4.7 ± 0.12 $^{b\S}$ | 4.6 ± 0.12 |
| | Triplet | 3.7 ± 0.13 | 3.8 ± 0.11 $^{a\S}$ | 3.5 ± 0.12 $^{b\S}$ | 3.9 ± 0.11 $^{a\S}$ |
| Weaning weight (kg) | Twin | 26 ± 0.83 $^{a\S}$ | 26.2 ± 0.61 $^{a\S}$ | 27.9 ± 0.68 $^{b\S}$ | 26.6 ± 0.68 |
| | Triplet | 25.5 ± 0.88 | 26 ± 0.68 | 25.2 ± 0.69 | 25 ± 0.68 |
| Growth rate to weaning (grams/day) | Twin | 251 ± 9.6 | 251 ± 7.2 $^{a\S}$ | 270 ± 7.8 $^{b\S}$ | 257 ± 7.94 |
| | Triplet | 246 ± 10.1 | 251 ± 8.1 | 240 ± 8.2 $^{a*}$ | 240 ± 8.1 |

No superscript = not significant (P>0.10); § P<0.10; * P<0.05.

Ewe pasture allowance from pregnancy scanning to tagging did not significantly affect lamb survival across all lambs over the same period (P>0.05). Twin lamb survival was higher than for triplets (P<0.01) and the interaction between pasture allowance and litter size at birth was significant at P<0.10. Twin and triplet lamb survival were not significantly different at the 8cm sward height and triplet lamb survival was lowest for lambs born to ewes allocated the 2cm pasture allowance and increased as pasture allowance increased (Figure 9.12).

*Figure 9.12 The effect of pasture allowance and litter size at birth on lamb survival at tagging (standard errors included).*




Ewe pasture allowance from pregnancy scanning to tagging (2, 4, 6 and 8cm sward height) and from tagging to weaning (4 and 8cm sward height) did not significantly affect lamb weaning weight and growth rate to weaning (P>0.05) (Table 9.11). Twin lambs were heavier at weaning and grew faster (26.7 ± 0.36 kg and 257 ± 4.2 g/day) than triplet lambs (25.4 ± 0.37 kg and 244 ± 4.36 g/day) (P<0.05).

Factors significantly influencing lamb weaning weight and growth rate to weaning included: ewe weight change over the same period and respectively) where ewes that gained more weight produced lambs with lower weaning weights (β=-0.01 ± 0.004, P<0.01; *r*=-0.27, P.001) and growth rates (β=–0.15 ± 0.044, P<0.001; *r*=–0.21; P<0.001). Lamb birth weight significantly affects weaning weight (β=2.39 ± 0.295, P<0.0001) and growth rate (β=15.73 ± 3.322, P<0.0001). Days from tagging to weaning significantly affected lamb weaning weight (β=0.29 ± 0.049, P<0.0001).

Time to ewe-lamb contact after tagging significantly affected lamb growth rate to weaning (β=-10.1 ± 4.474, P<0.05). Lambs grew at a slower rate to weaning if their dam took longer to make contact after tagging. Time for lamb to stand after tagging significantly affected lamb growth rate (β=9.34 ± 4.559, P<0.05). Lambs that were slower to stand after tagging grew faster to weaning.

Correlations were also performed to determine if there were any relationships between ewe and lamb behaviours and individual lamb performance (Table 9.12). Lambs born to ewes with higher MBS at tagging had quicker ewe-lamb contact times, stood and located the udder sooner and were significantly closer to their dams 5 minutes after tagging than lambs born to ewes with low MBS (Table 9.12). The longer it took for ewe-lamb contact, the longer it took for the lamb to stand, locate the udder and suck. The ewe also high bleated a greater number of times. Ewe high bleat frequency increased the greater the distance from their lamb five minutes after tagging (Table 9.12).

*Table 9.12 Correlations between lamb behaviour and performance traits across all litter sizes at birth.*

| | Time for ewe contact | Time to stand | Time to locate udder | Time to suckle | Time to follow | Distance from ewe |
|---|---|---|---|---|---|---|
| Birth weight | -0.13 * | ns | -0.15 * | ns | -0.22 ** | ns |
| Body length | -0.11 * | ns | -0.15 * | -0.23 * | -0.20 ** | ns |
| Weaning Weight | -0.09 § | ns | ns | ns | ns | ns |
| Growth Rate | -0.14 * | ns | ns | ns | ns | ns |
| Ewe high bleats | 0.74 **** | 0.48 **** | 0.31 **** | 0.26 * | ns | 0.38 **** |
| MBS | -0.50 **** | -0.23 **** | -0.18 ** | ns | ns | -0.32 **** |

ns= not significant (P>0.10); § P<0.10; * P<0.05 ** P<0.10, ***P<0.001 and ****P<0.0001.

There were some significant correlations adjusted by litter size. Twin lambs with lower birth weights took longer to make lamb-ewe contact (*r*=-0.13; P<0.10) after tagging. Twin lambs that were lighter also took longer to suckle from their dam after tagging (*r*=-0.22; P<0.10 and *r*=-0.34; P<0.05 respectively). Twin lambs that took longer to stand after tagging had higher weaning weights and growth rates (*r*=0.30 and *r*=0.28; P<0.001). Twin lambs that were quicker to follow their moving dam had higher weaning weights (*r*=-0.21; P<0.05). Ewe high bleating frequency after tagging was not significantly correlated with time to suckle for triplet lambs (P>0.05).

## 9.5 Discussion

Pasture allowance in late pregnancy and at lambing affected ewe and lamb performance and behaviour. Ewes with triplet litters were most affected. Twin litter weight at birth was similar for ewes grazing 2, 4 and 6 cm sward heights. However improvements in triplet litter weight at birth, weight of lamb weaned, litter survival to tagging and weaning were observed with increasing pasture allowance. Triplet lamb and litter survival to tagging increased by 15% from the lowest pasture allowance to the highest. Dam age and feeding level up to weaning did not affect the majority of ewe behaviour and performance traits.

Similar production benefits have been reported elsewhere. When multiple bearing ewes were offered additional feed in late pregnancy to increase liveweight, lamb mortality was reduced for single and twin born lambs (Scales *et al*., 1986). Scales and co-workers reported that a 10kg increase in ewe liveweight during the last 6 weeks of pregnancy resulted in a birth weight increase of 0.46kg in single and 0.52kg in twin lambs (Scales *et al*., 1986). Moore *et al*. (1986) reported that lambs born from high allowance ewes had higher rectal temperatures at birth than those born from low allowance ewes indicating the lambs poorly fed in utero tend to achieve high metabolic rates more slowly than those which receive a good nutrient supply (McCutcheon *et al*., 1981). Moore and co-workers (1986) also observed that an increase in lamb birth weight was associated with increasing lamb vigour, but an increase in lamb birth weight was associated with increasing rectal temperature only for male lambs.

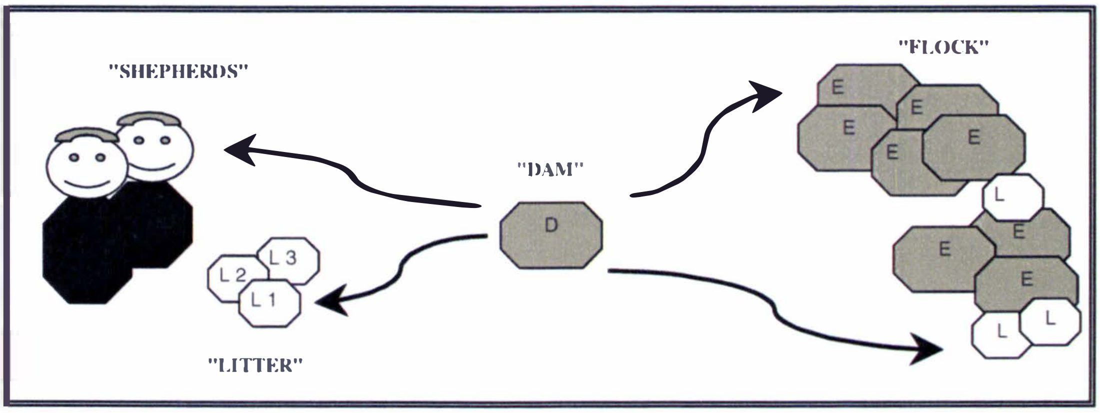
This study shows that lamb birth weight was affected by ewe pasture allowance in late pregnancy, however lamb birth weight was not significantly related to lamb behaviour after tagging. Astroshi and Osterberg (1979) studied prolific sheep and concluded that lamb birth weight influences behaviour but litter size does not, except indirectly through its affect on birth weight so that the smaller the lamb the less active it is. However results from Fahmy *et al.* (1996) contradict the previous authors, as they observed that Finn lambs, weighing half that of Suffolk lambs, were quicker to reach the udder after birth. Hight and Jury (1970) reported that lambs born to ewes fed well in late pregnancy are better equipped to survive conditions predisposing to exposure and starvation as they have more energy stored as brown fat reserves and maintain their suckling drive for longer than lambs born to poorly fed ewes. The effect of lamb birth weight on lamb behaviour is inconclusive and it is highly likely that a complex of physiological and genetic factors underpin lamb behaviour, not excluding the effect of maternal behaviour.

Maternal behaviour influences lamb behaviour providing evidence that maternal behaviour at parturition is critical to lamb survival (O'Connor *et al.*, 1985). However, according to Smith *et al.* (1966) "ineptitude of the lambs retards acceptance by the mother". According to Alexander (1988), mother-young acceptance is more likely if the newborn lamb does the following: stand soon after birth, suck soon after standing, follows the mother closely and moves to the mother if separated.

This study showed that triplet born lambs on the lower pasture allowance were less likely to stand, locate their dam's udder and follow their moving dam. Fewer triplet lambs bleated following tagging and before ewe contact and this may be why fewer ewes made contact. Lindsay *et al.* (1990) observed that increased vocal behaviour of lambs was strongly associated with earlier recognition of their mother and better bonding. This study showed that lambs were closer to their dam 5 minutes after tagging if the lamb had bleated when separated.

We investigated ewe maternal behaviour and lamb behaviour at tagging. Tagging temporarily separates a ewe and her litter. Ewes react differently to the separation, involving the shepherd. Depending on the strength of the bond formed with her litter, the fear for the shepherd, the visibility of her lambs versus flock lambs, the proximity of the flock and the ewe's 'drive' to be with the flock, the ewe will stay close to her litter or desert them in favour for the flock (Figure 9.13).

*Figure 9.13 Behaviour conflicts for the dam when her litter is being ear-tagged (where D= Dam, L1, L2 and L3 =Dam's Litter, L= Flock Lamb, E=Flock Ewe).*




Ewe feeding level did not affect MBS in this study. However ewes on higher pasture allowances were more likely to stay with their litter at the tagging site during the 5-minute observation period after tagging. Ewes with triplet litters on the 2cm sward height were on average a greater distance from their litter five minutes after tagging and high pitch bleated significantly more. These ewes were less likely to make contact with their lamb five minutes after tagging. Putu *et al.* (1988a) observed that nutrition during late pregnancy did not affect lamb desertion in single bearing ewes, but in the twin bearing ewes the low level of nutrition resulted in a higher proportion of permanent desertions of at least one of their twin lambs (19.2%) compared with ewes on a high level of nutrition (4.3%).

In humans, early maternal deprivation may be associated with social and educational retardation (Smith *et al.*, 1966). The maternal environment in utero and at birth affected birth weights and lamb survival to tagging but did not continue to impair lamb performance to weaning as lamb growth and weaning weights were similar between twins and triplets and between feeding levels. Napolitano *et al.* (1995) observed the average daily weight gain was lower in lambs that had been separated earlier from the ewe. This study showed that lambs that were slower to stand after tagging grew faster. Lambs grew an additional 10 grams per day for every minute they stayed lying down after tagging. Lambs that had quick ewe contact after tagging grew faster to weaning. Ewes that stay close to their litter during tagging and do not return to the flock are quick to make contact with their lambs. These ewes are more attentive to their lambs and this may explain why their lambs grow faster. A lamb that takes longer to stand after tagging is not as easily stressed as a lamb that stands quickly and flees. These 'content' lambs have faster growth rates to weaning. Murphy *et al*. (1994b) reported that animals of quiet temperament grow faster and are better producers than animals that are restless, nervous or aggressive. O'Connor (1996) suggested that the ewe-lamb relationship may be weaker for ewes and lambs that maintain close contact as the lamb ages, alternatively lambs may stay closer to ewes with lower levels of milk production especially where there is competition for milk from littermates. The interaction between the ewe and her lamb influences neonatal behaviour and changes with time (Lawrence and O'Connor, 1992).

Desertion may result from the conflict between flocking behaviour and the isolation associated with maternal behaviour (Kilgour and Szantar-Coddington, 1995). The arena test was used to identify behaviour differences and predict flocking and maternal behaviour in the ewe treatments. Behaviour in late pregnancy, in particular total distance travelled, was similar regardless of pasture allowance at this time. The most notable arena behaviour was that high-pitch bleating was more prevalent in ewes with triplets grazing the highest pasture allowance. This was difficult to explain as increased bleating has been linked to lower litter survival rates (Kilgour, 1998) and Dwyer *et al*. (1998b) suggested that high-pitched bleating is affected by ewe breed and may reflect the likelihood of separation of the ewe from the lamb. However the best mothers according to Lindsay *et al*. (1990), were those that were less active in stressful situations and those that bleated more often. It appears that some aspects of ewe temperament in the arena may predict production. In particular, ewes that take longer to approach the group sheep and therefore show reduced flocking behaviour have higher litter survival rates and ewes that high-pitched bleated had lower MBS at tagging.

It appears that lamb behaviour is more adversely affected than ewe behaviour by pasture allowance from pregnancy scanning to tagging and it appears that triplet lambs are more affected than twins. These results indicate the importance of considering the behaviour of both ewes and lambs as it would seem that it is not 'poor' maternal behaviour but inadequate lamb behaviour that is a limiting factor in triplet lamb survival on the lower pasture allowances. O'Connor and Lawrence (1992a) also found that it is lamb behaviour, not maternal behaviour that is the major factor limiting lamb survival. Shillito-Walser (1978) also appreciated the importance of effective lamb behaviour concluding that the formation of the maternal-offspring bond in sheep is the result of a rapid learning process influenced by the behaviour of both the ewe and the lamb.

## 9.6 Implications for Industry

The maternal environment inhibits the triplet lamb to a greater extent than a twin lamb (Chapter 3). Therefore ewes pregnancy scanned with triplets require considerably more attention for farmers to realise their production potential:

- Pregnancy scanning warrants adoption across the industry. It is no longer sufficient for ewes with "multiple" litters to be identified. Ewes with triplet litters should be identified and classified as priority stock. This will assist with management conditions when feed supply is low so that ewes with triplet foetuses are preferentially fed from ewes with twins. Farmers should strive for pre and post grazing pasture covers of 2000kgDM/ha (8cm sward height) for tripleting ewes.

- Ewe-lamb separation was more prevalent when ewes were grazing low 'pasture covers'. When the environment and management determine poor feed conditions at lambing, farmers may reconsider shepherding and tagging their lambs to avoid the possibility of ewe-lamb separation. They may leave tagging until the lambs are older or adopt an alternative method of permanent lamb identification.

- Increased birth weight is an advantage to the survival of triplet lambs suggesting that selection for multiple births should be accompanied by selection for increased birth weight. However this study shows that increased lamb birth weight is not the controlling factor affecting lamb behaviour. Further studies are required to investigate the inherent physiological factors of the lamb and of the maternal environment that effect lamb behaviour.

- Lamb behaviour requires more attention in animal selection programmes. In particular lamb bleating, time to stand and locate the ewe's udder all show promise as lamb survival indicators. Delayed standing following separation from its ewe at tagging, shows promise as a potential indicator for improved growth rate to weaning. Further investigation is required to determine the heritability of such traits.

# CHAPTER 10

# General Discussion

*Photograph taken by Julie Everett-Hincks*

Increasing the number of lambs born per ewe mated has been the focus for many New Zealand farmers for the past two decades. Financial returns were expected to increase with increasing reproductive rates (Geenty, 1997). However Amer *et al.* (1999) showed that above a litter size of 2.3 lambs born per ewe lambing, farmers can expect a reduction in farm profitability and there is a decreasing rate of economic gain per flock as litter size proceeds from 1.7 to 2.3 lambs per ewe. Triplets replace singles as litter size increases above 1.7 lambs per ewe and lamb mortality is assumed to be highest in triplets (Amer *et al.*, 1999). Farmers surveyed in this study were aware of the reduced financial returns caused by poorer survival rates in highly fecund sheep and identified lamb survival as the most important factor affecting farm income (Chapter 2). Farmers and researchers have redirected their focus to investigate methods of improving lamb survival in highly fecund flocks.

Farmers from the High lambing rate farms (Chapter 2) reported the same proportion of lamb losses to weaning as did the Low lambing rate farms that were surveyed. They attributed the reduction in lamb losses partially as a result of improved mothering ability. The survey identified the Coopworth breed as the predominant breed of High lambing percentage flocks (Chapter 2). A survey conducted by Rohloff *et al.* (1981) twenty years ago also attributed the increase in lamb rearing performance at that time to the use of the Coopworth breed.

Genetic parameters for lamb survival, litter survival and maternal behaviour score were derived for a Coopworth flock that had been selected for maternal ability and lamb survival for nearly 30 years (Chapter 3). Lamb survival was under minimal genetic control with the total heritability being just 16% (Chapter 3). Lopez-Villalobos and Garrick (1999) and Morris *et al.* (2000) reported heritabilities for lamb survival of a similar magnitude. The maternal effect of lamb survival attributed 11% of the total variation and the direct effect 14%, however the covariance between direct and maternal effects was negative. One possible explanation is that some of the genes that regulate survival are incompatible with the genes that enhance ewe-lamb bonding (Chapter 3). Identification of the genes responsible for lamb survival provides a challenge for the future. Farmers incorporating lamb survival into their animal selection programme must account for the negative correlation between direct genetic and maternal genetic effects on lamb survival, otherwise heritability estimates for lamb survival will be inflated and expected rates of genetic gain over estimated.

Farmers and animal breeders must also review how the lamb survival trait is currently recorded and analysed. Lamb survival is a complex trait, far more complex than the way it is recorded suggests. Lamb survival should be recorded for at least two stages, that is survival from birth to tagging (1-2 days of age) and survival from tagging to weaning (day 3 to day 100 of age). Most lamb deaths occur in the first two days from birth (Anon, 2002; Aspin 1997; Poindron *et al.*, 1984) and the strength of the ewe-lamb bond is determined in this first stage (Chapter 7 and 9) therefore lamb survival in the first 2 days of life is a different trait to lamb survival measured to weaning and warrants greater weighting in animal selection programmes. Genetic parameters for lamb survival should be estimated for survival to tagging, in addition to survival to weaning. This study has shown that genetic and environmental variation differs for lambs born as a twin or triplet and environmental effects play a greater part in triplet lamb survival than twin lamb survival. Greater genetic improvement in lamb survival is possible for highly fecund flocks if genetic parameters for lamb survival are separately estimated for ewes with a single lamb, twins and triplets. Farmers wanting to improve lamb survival should incorporate lamb survival to tagging and separate analyses for twins and triplets into their animal breeding programmes.

The selection strategy can be implemented following assessment of twin and triplet losses from current and historic data. Farmers should focus selection on the litter size where losses are largest and where gains in productivity are predicted to be greatest. Justification for implementing selection strategies based on litter size requires knowledge of the proportion of flock ewes with single, twin and triplet litters. An investigation into the predominant cause of death for each litter size will assist greatly when reviewing and implementing animal selection programmes to improve survival. For example twin lamb birth weight may be sufficiently large predisposing these lambs to dystocia whereas the predominant cause of death for triplets may be the starvation/exposure complex which is largely determined by environmental effects such as the weather. Triplets may only make up 5% of all lambs that are born and the weather is not easily controlled, although its adverse effect at lambing can be minimised by changing the lambing date and providing effective shelter (Pollard and Littlejohn, 1999), therefore productivity gains are more likely from implementing selection and management strategies to reduce dystocia.

Dam maternal behaviour score and litter survival were primarily influenced by the environment. The genetic parameters derived for the Coopworth flock for maternal behaviour score were low and the heritability estimates for MBS and litter survival were lower than those reported previously (Lambe *et al*., 2001; Haughey, 1984; Piper *et al*., 1984). Coopworth ewes in this study had a mean litter size at birth of 1.8 lambs per ewe and this was significantly higher than the litter sizes reported by Lambe *et al*. (2001). A possible explanation for the low estimate of genetic variance reported in this study may be that the proportion of variation attributed to environmental effects for maternal behaviour score and litter survival has increased with increasing litter size, as ewes with triplet litters had a more complex environment than ewes with a litter size of one or two. Future analyses should be performed separately for ewes with twins and ewes with triplets, as they were in this study.

Triplet lambs were constrained by the maternal environment provided by their dam, both genetically and through environmental effects (Chapter 3). The environment is critical for triplet litters, more so than for twins, as a greater proportion of the variation in triplet survival is attributed to environmental effects (Chapter 3). The environment accounts for 88% of the variation in triplet lamb survival and 75% for twins. Lamb and litter survival rates were high in this flock and it is likely that many years of selection for MBS have improved lamb and litter survival as variation in maternal ability was low and the majority of dams were classified as 'good mothers' (MBS 3 and above). This flock and other high performing sheep flocks, require a new 'maternal ability indicator' that detects genetic variation in litter survival. Further work is required to elucidate the underlying genetic causes of the maternal effects for lamb survival and the direct effect for dam litter survival.

Kilgour (1998) showed that arena behaviours could be used to predict lamb rearing ability in Merinos. Merino ewes with higher lamb rearing performance travelled only 60% as far and bleated fewer times than a random flock (Kilgour, 1998). In this study, Romney ewes that showed less flocking behaviour in the arena test and high bleated fewer times had greater lamb rearing performance at weaning (Chapter 8, 9). These arena behaviours consistently predicted lamb rearing performance in Romney ewes selected for High and Low IGF-1 with single and twin litters (Chapter 8) and Romneys with twin and triplet litters subjected to different feeding management (Chapter 9). Arena behaviour appears to be under genetic control as ewes selected for High and Low IGF-1 showed less flocking behaviour than the unselected Control flock and feeding level in late pregnancy did not affect arena behaviour in ewes with larger litter sizes.

The relationship between arena behaviour and maternal behaviour was not strong, however ewes that showed higher flocking behaviour in the arena also showed increased flocking behaviour at tagging, as was shown by their lower MBS (Chapter 8). Maternal behaviour score varies with breed, selection line and litter size, therefore it should be used with caution. The MBS with a modified scale may be more suitable for some sheep genotypes, while other genotypes may require their own maternal ability indicator. An alternative indicator showing promise is ewe-lamb contact time after separation induced at tagging (Chapter 9). Finn and Texel flocking behaviour, as shown by their MBS (Chapters 6 and 7) differed markedly and therefore an opportunity exists to use these breeds as a model to explore whether a stronger relationship exists between arena behaviour and maternal behaviour.

O'Connor *et al.* (1985) reported that ewe age, ewe genotype and litter size significantly influenced MBS in a study of several ewe genotypes under New Zealand farming conditions. The mean litter size was 1.67 lambs per ewe and MBS increased with increasing litter size (O'Connor *et al.*, 1985). The authors suggested that an increase in MBS with increasing litter size may represent a stimulation of maternal behaviour by additional lambs, suggesting that ewes with higher MBS at tagging are more attentive towards their lambs and this may explain why in this study Coopworth ewes with an MBS of 4 compared to Coopworth ewes with an MBS of 3 weaned an additional 10 kg of lamb. O'Connor *et al.* (1985) observed an improvement in weight of lamb weaned per ewe mated with increasing MBS. The Coopworths in this study had been selected for maternal ability for nearly 30 years. It is likely that they were more receptive to the needs of their litter and adjusted their maternal behaviour accordingly, more than their East Friesian Coopworth cross contemporaries who had not yet been intensively selected. Finn and Texel ewes with a maternal behaviour score of 4 also weaned an additional 10 kg of lamb than ewes with an MBS of 3 (Chapter 7).

O'Connor and Lawrence (1992a) investigated lamb and ewe behaviour in Scottish Blackface and Scottish Blackface Bluefaced Leicester crosses. They suggested that it is not 'poor' maternal behaviour but inappropriate lamb behaviour that is the limiting factor in lamb survival for the crossbreds. However they remained unconvinced of the degree to which lamb behaviour influences ewe behaviour. This thesis investigated the interaction between ewe and lamb behaviour in larger litter sizes and highlighted the importance of lamb behaviour in ewe-lamb attachment (Chapter 6, 7, 9).

Triplet lambs rely on their own genetics (direct genetics) to ensure their survival to weaning (Chapter 3). Cloete *et al.* (2002) have shown that lamb behaviour, in particular time to stand and time to suck do have a genetic component and that it differs between breeds. However further work is required to determine the genetic variation of lamb behaviours in large litters. Lamb behaviour at tagging was not affected by breed and lambs that stand after tagging and suck from their dam had an improved chance of survival (Chapter 7). The chance of lamb survival improved 3-fold for a lamb that suckled from its dam within ten minutes from tagging compared to a lamb that did not. The chance of survival to weaning improved 5-fold when a lamb stood within ten minutes from tagging (Chapter 7).

Lambs that stood quickly after birth took longer to stand 5 to 8 hours later at tagging (Chapter 7). As lamb age progresses, the ewe-lamb bond strengthens and lambs and ewes are more aware of each other's proximity after separation. The lamb can better determine the proximity of its dam from a combination of auditory and visual cues. Ewes with lower MBS high bleated more (Chapter 7, 9) and ewes with higher MBS low bleated more (Chapter 7). The dam also relies on auditory and visual cues to become reunited with her lamb and will high bleat more the longer it takes for the lamb to stand (Chapter 9). The dam will high bleat when she has lower MBS and cannot locate her lamb or litter. Lamb bleating represents need (Chapter 6) and attracts the dam when separated (Chapter 9). The lamb bleats more if its dam has a lower MBS (Chapter 7) and it will bleat more if it stands quickly (Chapter 9). This interactive behaviour between the dam and her lamb following separation may explain why younger lambs that stand after tagging have a better chance of survival (Chapter 7) and why older lambs that took longer to stand after tagging grew an additional 10 grams per day for every minute they remained lying down (Chapter 9). Quicker ewe-lamb contact times were also associated with faster lamb growth rates (Chapter 9). The Finn and Texel lambs were tagged when they were between 5 and 8 hours old (Chapter 7) whereas the Romney lambs were about 10-12 hours old (Chapter 9). Ewe-lamb attachment is not as strong for younger lambs and therefore a lamb that stands after tagging is more visible, improving its chance of being reunited with its dam and improving its chance of survival. The older lambs were more aware of their dam's proximity. These lambs appeared more 'content' suggesting that lamb growth rate up to weaning warrants investigation as a possible indicator for future lamb rearing ability. Murphy *et al.* (1994b) reported that animals of quiet temperament grow faster and are better producers than animals that are restless, nervous or aggressive.

Ewe MBS tended to improve throughout the lambing season with increased shepherding frequency (Chapter 3). The survey identified increased shepherding as the probable cause of increased lamb production by maintaining low lamb losses in the High farm group (Chapter 2). Markowitz *et al.* (1998) suggested that domestic animals that are socialised to humans are more easily managed and less timid than those that were not. Past research has shown that poor maternal behaviour in primiparous ewes is often considered a cause of lamb death (Arnold and Morgan, 1975) as these younger and inexperienced ewes show more frequent abnormal post lambing behaviours than older ewes (Sharafeldin and Kandeel, 1971). Therefore research is required to determine if ewe lamb breeding replacements can be trained to the presence of the shepherd to reduce emotivity, reduce flocking behaviour and improve mothering ability. Research should also be extended to ewe breeds that show a greater degree of flocking behaviour, such as the Finnish Landrace (Chapter 6 and 7).

Shillito-Walser (1978) stated that the formation of the ewe-lamb bond is the result of a rapid learning process influenced by the behaviour of both the ewe and the lamb. Pollard (1989) showed that lambs of larger litters assume a greater role in maintaining contact with their dam and younger lambs had difficulty maintaining contact. Further investigation is required to determine whether lamb behaviour is learned from dam behaviour and if lamb behaviour in large litters is influenced by the behaviour of littermates.

Researchers and farmers are aware of the effect of maternal nutrition on lamb survival. The majority of studies suggest that maternal under nutrition reduces lamb survival through its affect on lamb birth weight (Moore *et al.*, 1986; Scales *et al.*, 1986; Dwyer *et al.*, 2003). This study showed that ewe nutrition in late pregnancy affected triplet lamb behaviour and survival to weaning, regardless of birth weight. Ewes with triplet litters grazing 2cm pasture sward height in late pregnancy produced lambs that were slower to stand, locate their udder and follow them after tagging. These ewes took longer to contact their lamb after separation. Triplet lamb survival was similar to twin lamb survival when pasture allowance was not restricted in late pregnancy. Lamb behaviours observed after tagging, such as time to stand and suck were not explained by lamb birth weight. Further investigation is required of the physiological mechanisms that determine lamb behaviour resulting from changes in the maternal environment.

Some studies have investigated the effect of maternal nutrition on maternal behaviour (Dwyer and Lawrence, 1992; Dwyer *et al.*, 2003). However these studies have either focussed on maternal behaviour of ewes with small litter sizes (Dwyer and Lawrence, 1992) or researched maternal behaviour where ewes and their lambs were housed indoors (Dwyer *et al.*, 2003). MBS was not affected by pasture allowance for ewes with twin and triplet litters (Chapter 9) and for Finns and Texels (Chapter 5, 6, 7). MBS measures the distance a ewe retreats from her lamb when it is tagged by the shepherd and does not measure the time taken for the ewe to return to her litter. In contrast ewe-lamb contact time after tagging showed that ewes grazing lower sward heights took longer to contact their triplet lambs after tagging (Chapter 9). Ewe-lamb contact time appears to be a more suitable indicator and possibly a more effective selection tool than MBS for lamb rearing performance. Particularly for breeds that show reduced flocking behaviour and where environments were more diverse. However further research is required, including the estimation of genetic variation and its correlation with production traits.

A relationship was found between MBS and change in ewe body condition (Chapter 4). Ewes that maintained body condition in late pregnancy provided a more suitable maternal environment to grow and support their litters. Ewes with higher β-hydroxybutyrate levels were not as receptive to the demands of their litter and had lower MBS (Chapter 4). Higher β-hydroxybutyrate levels indicate that the ewe's nutritional demand is exceeding supply, possibly impairing a ewe's ability to bond effectively to her litter and/or encouraging these ewes to travel further from the birth site and the litter in search of food. Stock management tools, such as pregnancy scanning to diagnose foetal number and body condition scoring to monitor ewe condition should be employed to ensure that the energy demands of the pregnant and lactating ewe are met to improve lamb rearing performance.

Ewe and lamb attachment behaviour is complex and the degree of complexity increases as litter size increases. For small litter sizes dam rearing success is determined by maternal behaviour, however for larger litters dam rearing success is determined by lamb behaviour and the lamb's interaction with its dam. Future research should focus on the behaviour of litters and how litter behaviour influences dam behaviour.

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