beef+lamb new zealand

HOGGET PERFORMANCE

UNLOCKING THE POTENTIAL

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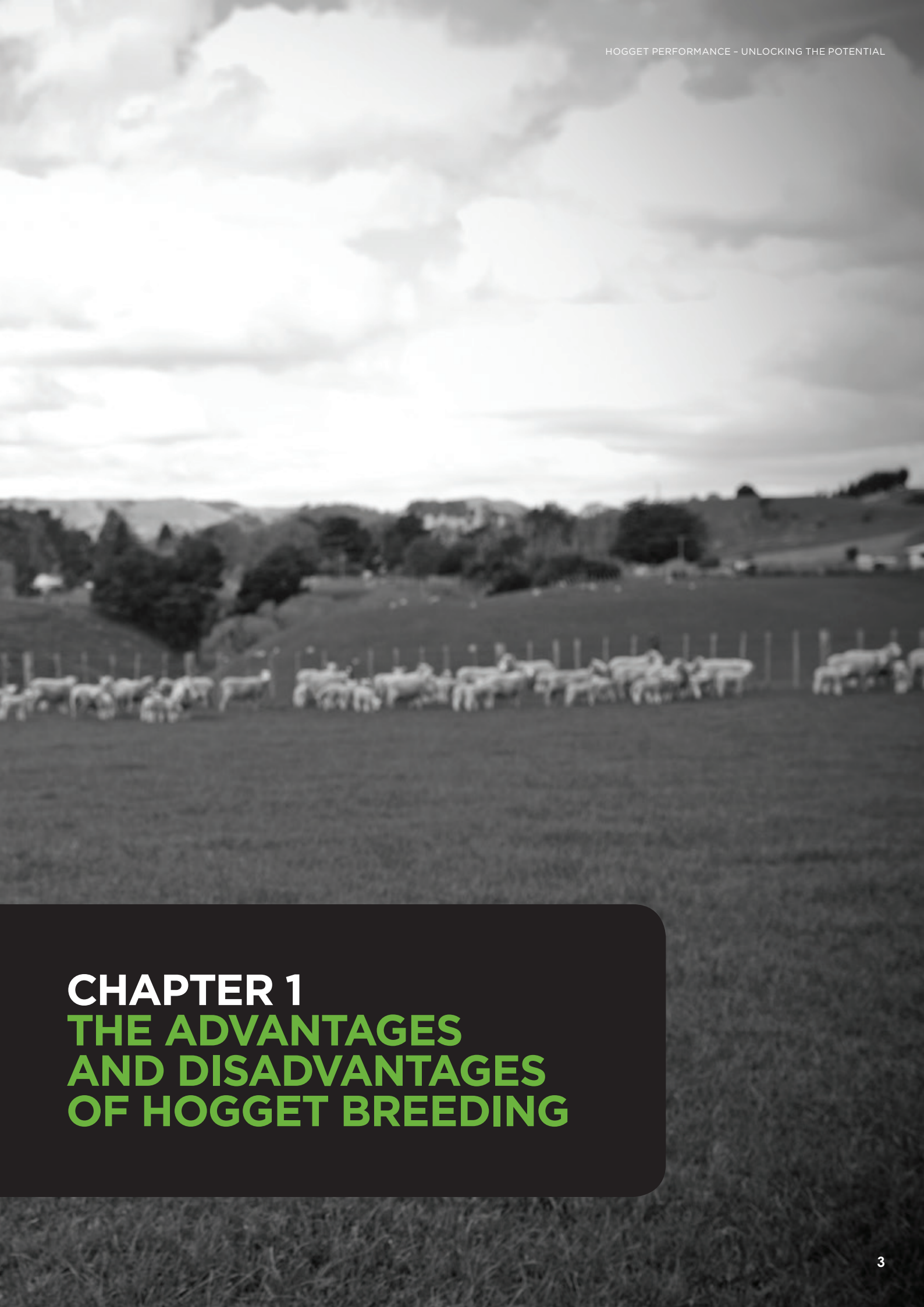


CHAPTER 1
THE ADVANTAGES AND DISADVANTAGES OF HOGGET BREEDING

A number of potential advantages are claimed for ewe hogget breeding. However given that a greater proportion of farmers choose not to breed ewe hoggets than those that do, there are obviously some potential disadvantages or limitations to this management option.

Potential advantages include:

- the production of a lamb within the first year of life
- more efficient use of herbage in spring
- more lambs produced on farm within a given year
- higher net income through the sale of more lambs
- an early selection/screening tool for ewe replacements
- an increase in ewe lifetime reproductive performance
- more progeny born on farm which can increase selection pressure if replacements are selected from those born to hoggets
- a potential reduction in the generation interval if progeny born to ewe hoggets are selected as replacements.
- a potential reduction in lifetime greenhouse gas emissions per unit of product produced if lifetime productivity is increased

Potential disadvantages include:

- often low and variable reproductive performance of ewe hoggets
- increased feed requirements during the hoggets first year of life, especially during their first winter
- the need for hoggets to achieve live weight targets at eight months of age, adding more pressure to the farming system during the summer/autumn period
- if the ewe hogget experiences 'hardship' during her first pregnancy and lactation, or is poorly managed, there is the potential for reduced two-year-old live weight and reproductive performance. Which may have negative impacts later in life
- progeny born to ewe hoggets often have lower survival rates and lower liveweight gains to weaning
- ewe hogget breeding is often associated with extra costs – such as the requirement for more rams and vasectomised (teaser) rams
- breeding ewe hoggets adds another priority stock class to the farming system which reduces flexibility
- hogget breeding can increase workload.
- the potential for a higher death rate in lambing hoggets
- reduced wool production at hogget and two-tooth shearing
- the potential for reduced longevity in the ewe flock

Each farmer must weigh up the potential advantages and disadvantages for their own system before deciding whether or not to breed ewe hoggets.

CHAPTER 2
PRE-MATING MANAGEMENT OF EWE HOGGETS

Breeding season and matching feed supply

The timing of hogget breeding date is determined by the onset of reproductive activity in hoggets. In traditional breeds such as the Romney, Coopworth and Perendale this is four to six weeks later than for mature ewes. A hogget must first reach puberty before it can be bred. Finnish Landrace and East Friesian ewe hoggets, and composites which include these generally reach puberty earlier than the traditional breeds. Finnish Landrace and East Friesian ewe hoggets are more likely to start reproductive activity in early – to mid-April, compared to late April/early May for the traditional breeds.

Breeding in early May allows for late pregnancy and early lactation to coincide with the period of increased herbage growth on many farms. However, a side effect of this in some areas, especially summer dry regions, is that feeding levels in late lactation can be a problem due to a decline in herbage quality and quantity. Therefore timing of breeding is not only important for breeding success but also for potential impacts later in the year.

An earlier breeding date, for example mid-April, might be considered as it allows for an earlier weaning of lambs born to ewe hoggets, giving the young dam more time to gain liveweight prior to rebreeding as a two tooth. However, due to the timing of the onset of reproductive activity in hoggets the performance achieved with a mid-April mating might be disappointing. Further, earlier breeding may result in the late pregnancy period occurring before spring herbage growth, which might limit the performance of the hogget and her offspring.

Farmers are advised, perhaps with help from a farm advisor, to determine the impact of breeding date on the feed demand profile on their own farm and its match with feed supply. Breeding ewe hoggets results in an additional class of priority stock during the winter period. Therefore farmers must either ensure extra feed is available for these pregnant hoggets, over and above that which would be otherwise required for non-pregnant ewe hoggets, or alter the numbers of animals in other stock classes.

Stage of hogget breeding season and conception rate

Poor egg quality has been stated as one of the factors responsible for low conception rates in hoggets. However, egg quality and conception rates appear to improve after the first hogget oestrous cycle. This further strengthens the argument for not trying to breed hoggets too early in the season.

The use of teasers (the ram effect)

There are two reasons for utilising the “ram effect” with ewe hoggets. Firstly, the ram effect can result in more ewe hoggets being bred in the first cycle (17 days) for a May breeding and secondly there is the potential to advance the onset of breeding, allowing for the breeding of ewe hoggets to occur in early – to mid-April.

The introduction of vascectomised rams (teasers) for a period of 17 days immediately prior to ewe hogget breeding has consistently been shown to increase the proportion of hoggets bred in the first 17 days of breeding for a traditional 1 May breeding date. It appears the optimal teaser to ewe hogget ratio is in the range of 1:70 to 1:100. It is important that teasers are used in teams to ensure ewe hoggets get maximum exposure to the male. It is his pheromones (smell) that are thought to induce the breeding activity in the ewe hogget. Studies have shown that teaser to ewe hogget ratios as large as 1:200 can result in more ewe hoggets being bred early in the breeding period, in comparison to not utilising a teaser at all. Although a teaser ratio of 1:200 is not as effective as a lower ratio.

It is very important that teasers are used for a period of 17 days only. This is because exposure to the teaser results in reproductive activity, therefore breeding, starting 17 to 26 days after the introduction of the teasers to responsive ewe hoggets. A common mistake is to expose ewe hoggets to vasectomised rams for 21 days. This results in some ewe hoggets displaying reproductive activity in the 4 days before the entire ram is introduced and therefore they will not be in receptive to the ram again until 13 days after the ram is introduced resulting in a later than expected average day of mating. It is also important to note that for the ram effect to be effective farmers need to ensure ewe hoggets have not been recently exposed to rams prior to teasing i.e. it is the novel exposure to a male that induces the effects. Hoggets which have already reached puberty themselves will not respond to teasing. Therefore in relatively heavy mobs of hoggets, with average live weights of 45 kg or greater, there may be little advantage in using teasers.

A few farmers may wish to try to breed ewe hoggets in early – to mid-April. This has flow on effects, if successful, of allowing for a relatively early weaning date or heavier lambs during lactation at a given date. The use of teasers in the late-March and early-April period has met ith some success. However, for it to be successful, hoggets still need to achieve the same target breeding live weights and it appears that ewe hoggets of better body condition score are more likely to respond to such an early teasing.

Some farmers may not wish to use teasers, as they can be relatively expensive to produce and are only utilised for a very limited period of the

year. Alternatives examined include exposing ewe hoggets to short scrotum ram lambs (often termed cryptorchid) and mature intact rams. At ratios of one short scrotum ram lamb: 60 ewe hoggets studies have shown no effect. It is possible that lower ratios maybe more effective, although this has not been experimentally examined. The use of entire mature rams for 17 days prior to the normal start of breeding is very likely to have the same effect as a 17-day teasing period with vasectomised rams. However it comes with the added risk of early pregnancies. Therefore if farmers wish to utilise this approach to induce puberty in ewe hoggets, the use of ram harnesses are advocated as a means of identifying which and when hoggets are bred.

Figure 1: Relationship between ewe hogget mating weight and scanning percentage

Adapted unpublished data, kenyon et al.

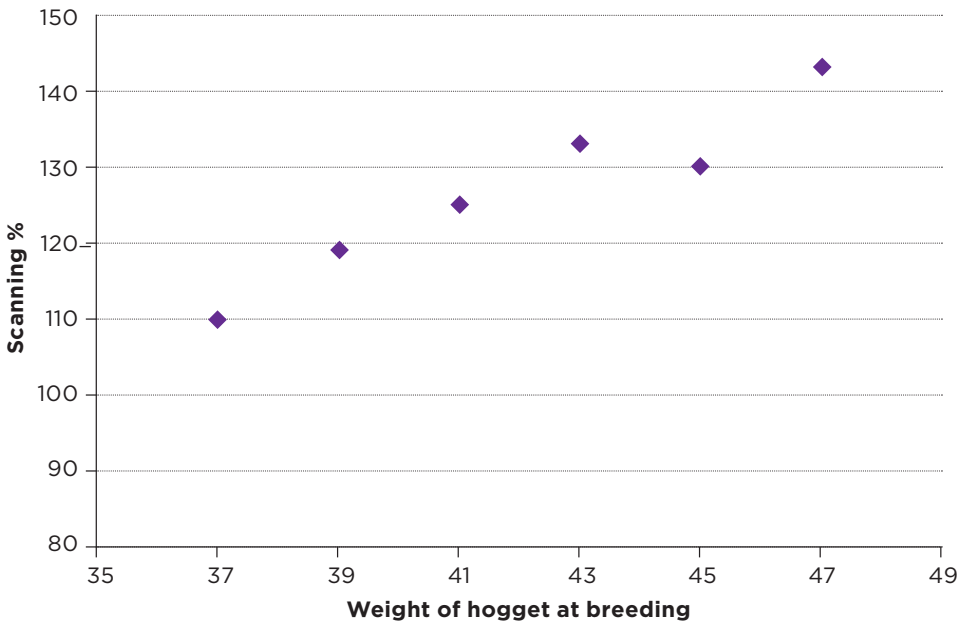


Table 1: Effect of condition score two months pre-breeding on ewe hogget breeding performance

Condition score	% bred in first 17 days of breeding	% not bred during a 34-day breeding period	Pregnancy scanning performance (%)
1.5	52	9	91
2.0	65	6	109
2.5	76	4	127
3.0	77	3	129
3.5	84	1	154

Note: Data from more than 3500 ewe hoggets whose mean live weight two months pre-breeding was 37 kg and mean live weight at breeding was 41 kg. Kenyon et al. (unpublished data)

Table 2: Effect of an extra kg in singleton bearing ewe hogget live weight at various stages of pregnancy on lamb birth weight, lamb weaning weight and weight of the ewe hogget at weaning

Day of gestation	Effect on lamb birth weight	Effect on lamb weaning weight	Effect on hogget weight at weaning
0	16g	327g	1361g
50	9g	248g	1093g
100	5.4g	143g	745g
At term	3.7g	106g	550g

Table adapted from Schreurs et al 2010a

Table 3: The metabolisable energy requirement per day (MJ ME/d) for ewe hoggets prior to hogget breeding.

Live weight gain /day (g)	Live weight (kg)				
	28	**32**	**36**	**40**	**44**
0	6.0	6.8	7.5	8.3	9.1
50	8.4	9.4	10.4	11.4	12.4
100	10.9	12.1	13.4	14.6	15.7
150	13.4	14.9	16.4	17.8	19.1
200	16.0	17.7	19.4	21.0	22.5
250	18.6	20.5	22.5	24.2	25.9

This is based on a pasture with an ME of 11 and includes an 8% wastage factor (Brookes unpublished).

Breeding live weight and body condition score

To breed successfully, hoggets must have reached puberty. In sheep puberty occurs when the animal is somewhere between 40 and 60% of its mature live weight. Therefore hogget breeding live weight is one of the major determinants of the number of hoggets successfully bred, and the performance of the hogget and that of its offspring to weaning.

Target breeding live weights and body condition scores

Individual ewe hoggets should be a minimum of 40 kg live weight at breeding (for a flock with a two tooth mating weight in the range of 60 – 65 kg). Across a number of studies it has been clearly shown that there is a positive relationship between ewe hogget live weight at breeding and reproductive performance, up until at least 50 kg, although there is some evidence to suggest a tapering off of the live weight effect above 45 kg (Figure 1). A rule of thumb that has been suggested is that for every 1 kg of live weight at breeding an extra 2% in lambing percentage will occur. Therefore there are clear advantages of having ewe hoggets as heavy as possible at breeding. However, it should be noted that ewe hoggets can become pregnant, and many do, at live weights well below 40 kg. Breeding at low live weights can have negative flow on effects for the young dam and her progeny.

Instead of selecting ewe hoggets suitable for breeding based on live weight an alternative approach is to select based on body condition score. It has been shown that ewe hogget body condition score affects the proportion of hoggets successfully bred early in the breeding period and the number of fetuses per hogget (i.e. the scanning percentage). Farmers could use body condition scoring as a screening tool to identify hoggets most suitable for breeding. Table 1 indicates the effect of body condition score approximately two months prior to breeding on subsequent hogget breeding performance and scanning percentage. The data clearly indicate that it is possible to identify ewe hoggets most suitable for breeding well before the start of mating.

Hogget live weight at breeding has a clear positive effect on the live weight of the ewe hogget and her offspring at weaning (Table 2). The weight of the ewe hogget at weaning also has implications for her as a two-tooth. It is probable that well grown hoggets at breeding are also less likely to suffer from dystocia (birthing difficulties) as their pelvic size in relation to lamb birth size will be more appropriate. It has been shown that for every kg a single bearing/rearing ewe hogget is heavier at breeding her lambs will be 327 g heavier at weaning and she herself will be 1.36 kg heavier at weaning, as she will be more able to cope with the rigours of pregnancy and lactation. The table also indicates how small an impact ewe hogget live weight has on lamb birth weight, indicating the importance of genetic control on birth weight.

It is important that farmers monitor the live weights of their ewe hoggets, from weaning until the start of breeding, to ensure they reach target breeding live weights. The earlier a potential problem is identified the easier it can be rectified. If a ewe lamb is weaned at 30 kg on 1 January and gains live weight at just 100 g/d, she will weigh approximately 42 kg on 1 May (see appendix 1). Alternatively if she gains live weight at 150 g/d she will weigh approximately 48 kg on 1 May. To monitor the live weight of a mob, only 50 ewe hoggets need to be weighed monthly to get an indication of their progress. To achieve live weight gains rates in excess of 100 g/d, ewe hoggets should be offered good quality herbage with grazing masses above 1200 kg DM/ha and allowances above 3 kg DM/day (Figures 2 and 3). Once pasture covers fall below this level intakes will begin to be restricted. Table 3 indicates the daily requirements for ewe hoggets either maintaining or gaining live weight.

Breed differences

Finnish Landrace and East Friesian hoggets, and composites based on these breeds can reach puberty at relatively low live weights (e.g. 30 – 35 kg) in early – to mid-April. However, minimum breeding live weights of 40 kg are still advocated if these breeds and their composites are to express their natural reproductive advantage. Therefore it is important that farmers understand that the use of these genetics should not be considered as a substitute for inadequate hogget breeding live weights. While breeding these breed types at low live weights might allow farmers to achieve suitable pregnancy scanning results, the weaning percentage and the weight of the lambs and that of the ewe hogget at weaning are likely to be disappointing.

Research has shown that in comparison to Romneys, hoggets with 1/16 to 1/2 East Friesian or Finnish Landrace genes had a 13.5% increase in number of lambs docked per hogget presented for breeding. While those with at least 50% of these genes or greater had a 23% increase in docking percentage above that observed in Romneys. Coopworth ewe hoggets were reported to have an almost 11% greater docking percentage than Romneys.

Should all hoggets be presented for breeding?

The answer to this question will vary from one farming situation to another. If all ewe hoggets are above 40 kg live weight at breeding, and the predicted feed budget indicates that there is the feed available for this additional priority class of

stock during the winter period, then all hoggets could be presented for breeding. However on many farms, dry environmental conditions over the summer/autumn period may mean that not all hoggets will reach their target live weights. Dry conditions can also result in herbage covers going in winter being lower than optimal. In this situation, farmers should consider only breeding a limited number of their heavier hoggets.

Farmers considering breeding ewe hoggets for the first time are strongly advised to only breed a proportion of their hoggets in the first year (the heaviest ones) so as to become accustomed to the changes in management required to be successful at breeding ewe hoggets. Over the following years they might slowly increase the proportion bred. It is also important for farmers to realise that the number of ewe hoggets they present for breeding each year may vary depending on hogget live weight and the current and predicted feed availability.

Farmers also need to realise that if a ewe hoggets is bred at a live weight of less than 40 kg it will require more feed in the following 12 months to get to a suitable two-tooth breeding weight than those hoggets which were heavier at hogget breeding. In addition, as outlined previously, the performance of lightweight hoggets and their offspring is less than that of their heavier counterparts.

The effect of shearing ewe hoggets prior to and during breeding

Shearing of ewe hoggets in the period between weaning and the month prior to breeding has been associated with a small increase in lambing percentage. The mechanism for this effect is unclear. It may be due to improved feed intake and live weight gain as some studies have reported that shearing can help with heat loss and stimulate appetite. There are few reported studies which have specifically examined the effect of shearing ewe hoggets less than one month prior to breeding. However, shearing is one of the greatest stressors a sheep faces in its life, and stress is known to affect cycling in mature ewes. Therefore, shearing just prior to and during the breeding period is not advised.

Figure 2: Effect of pasture allowance and varying herbage types on lamb live weight gain

From: Jagusch et al. 1978

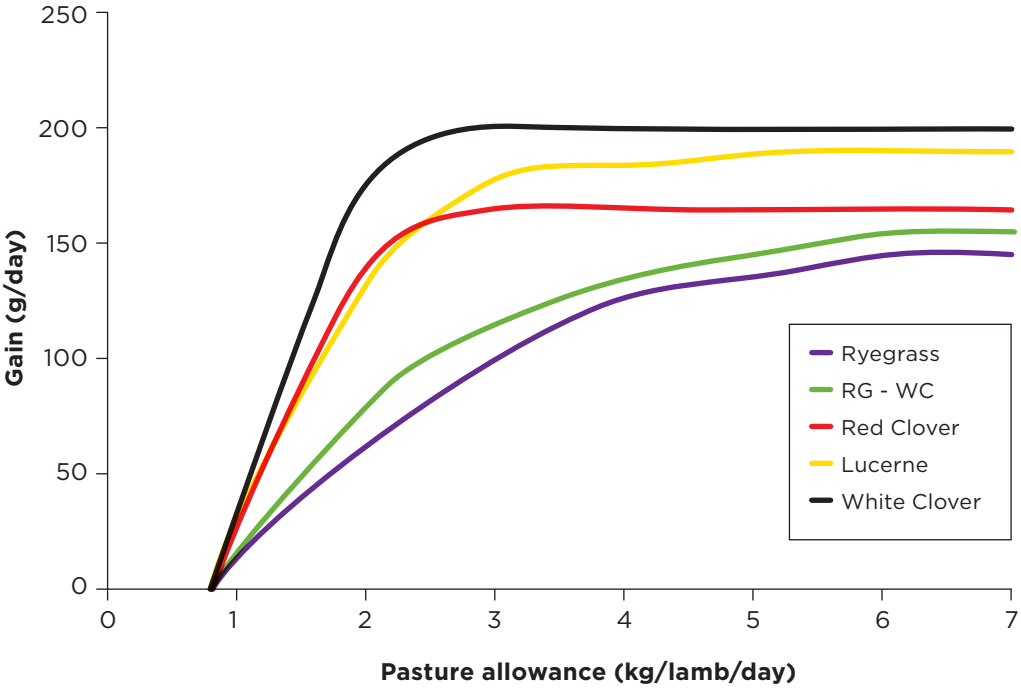
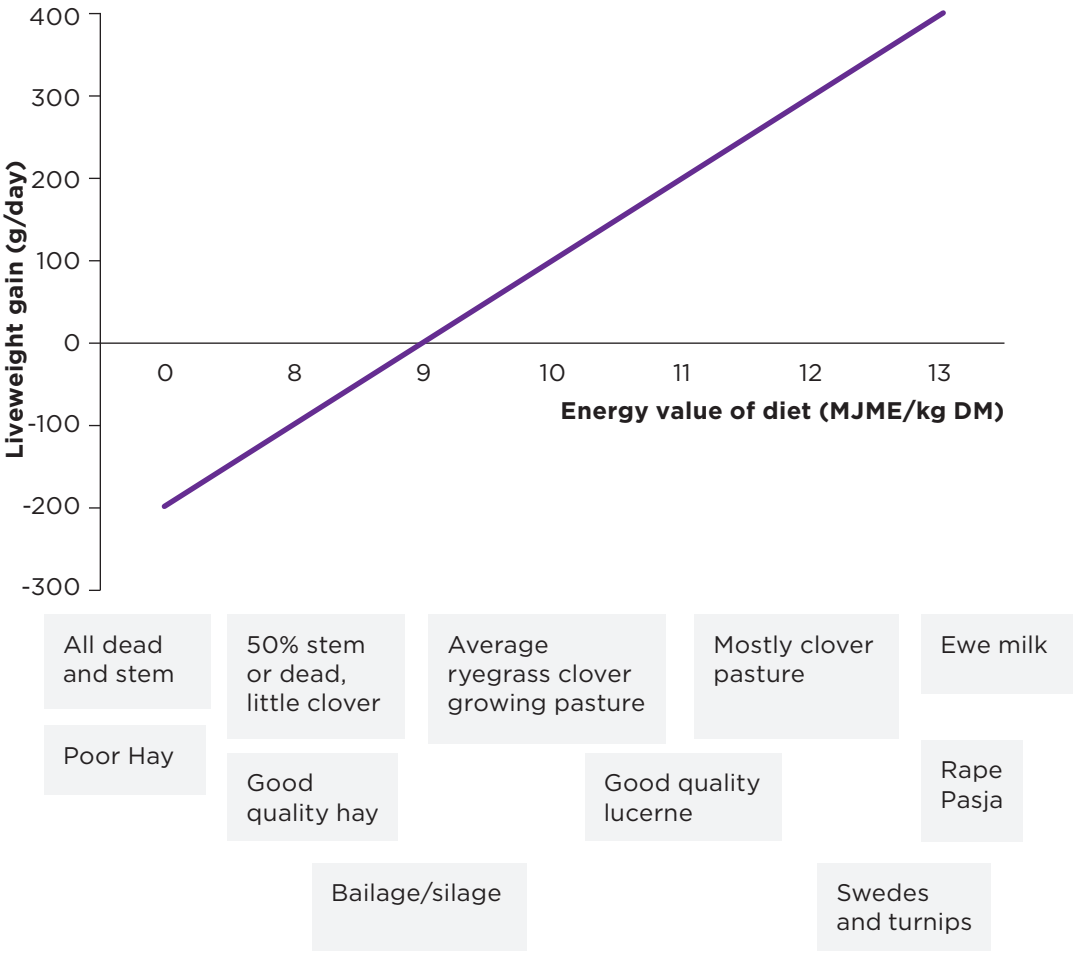


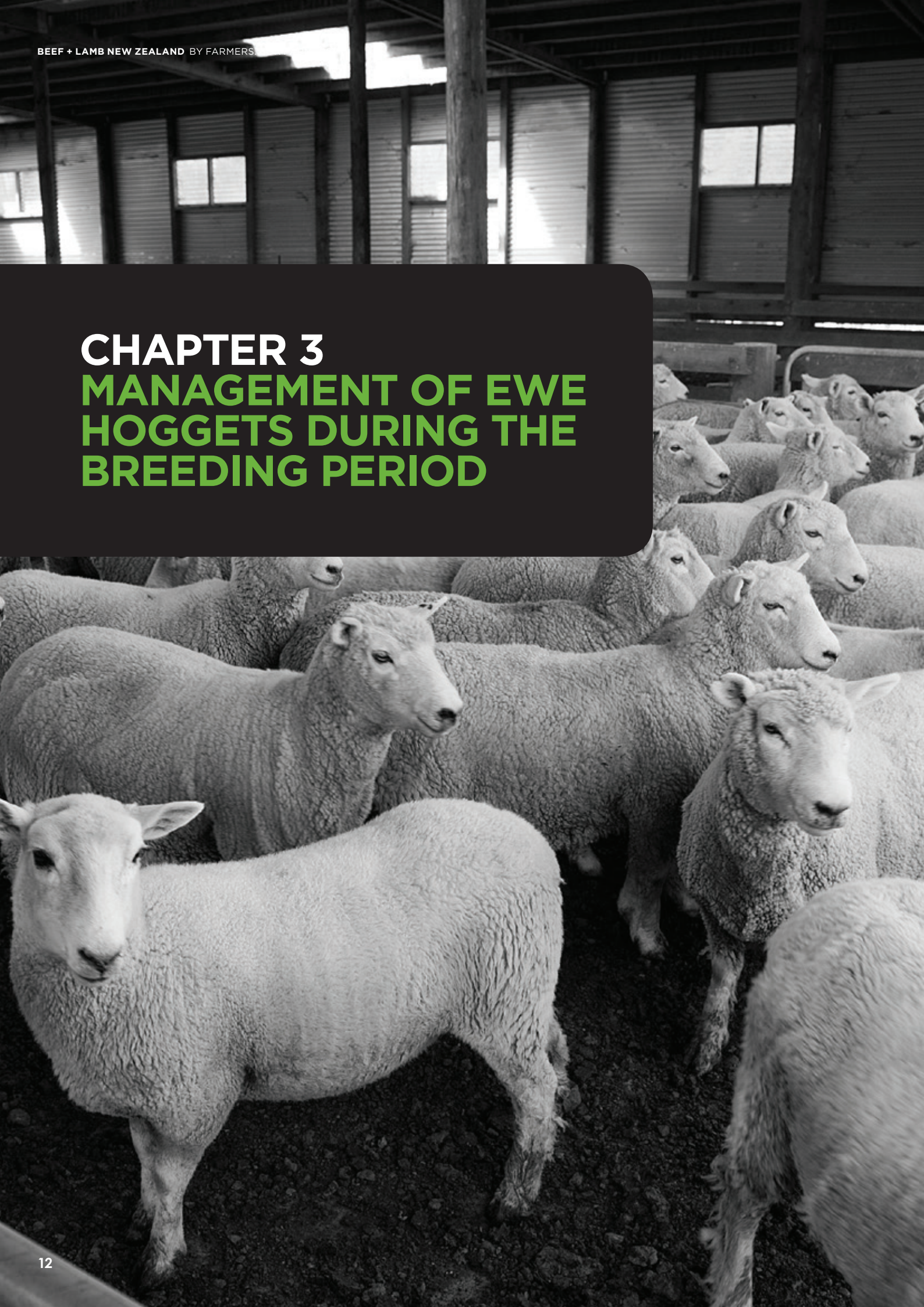
Figure 3: Effect of diet energy value on the growth rate of a 30 kg lamb



Animal health management

Ewe hoggets are prone, due to their naivety, to abortion caused by Toxoplasmosis and Campylobacteriosis. It is recommended that hoggets are vaccinated against both of these diseases pre-breeding. Salmonella brandenburg also causes abortion in some (particularly southern) areas of New Zealand. In these areas, it is recommended that hoggets are vaccinated against this also.

Farmers are encouraged to discuss with their veterinarian other health issues that might affect hogget performance e.g. internal parasites, pneumonia, facial eczema and mineral deficiencies. Farmers should have an animal health plan in place. Any health issues that negatively affect growth of the hogget will have negative flow-on effects in terms of hogget reproductive performance.



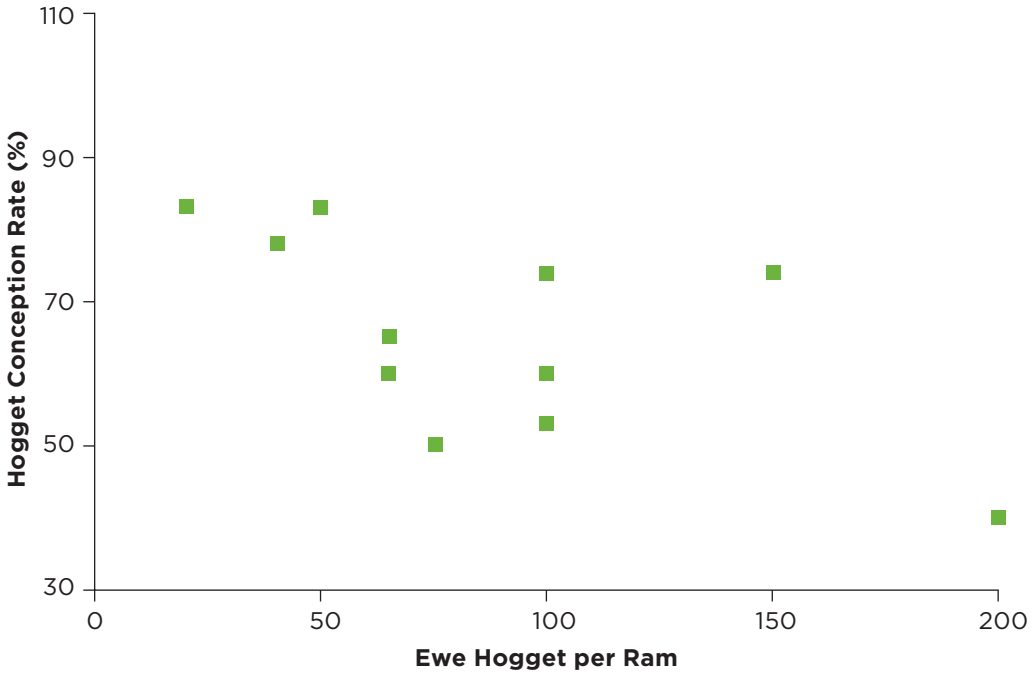
CHAPTER 3
MANAGEMENT OF EWE HOGGETS DURING THE BREEDING PERIOD

Introduction

Hoggets gaining live weight during breeding will display greater reproductive performance than those either maintaining or losing weight. There is some evidence from the United Kingdom, using concentrate rations, to achieve very high live weight gains in excess of 200 g/d can be associated with poorer conception rates. This response has generally not been found under pastoral based systems in New Zealand. However farmers are advised that due to this potential issue, during the breeding period hoggets should be gaining live weights in the range of 100 – 150 g/d.

Figure 4: Effect of ram ratio on hogget conception rate

Adapted from. Stevens and McIntyre 1990.



A further advantage of hoggets gaining live weight during the breeding period is that those which have not reached puberty may do so.

To achieve live weight gains of 100 – 150 g/d during the breeding period hoggets must be offered good quality herbage and if on a ryegrass white cover sward post grazing pasture masses should not be below 1200 kg DM/ha.

Breeding behaviour

Ewe hoggets are 'shy' breeders, they are less likely to seek the ram and to stand for him and are in oestrus (heat) for a shorter period than mature ewes. Therefore farmers need to maximise the chance that the ewe hogget comes into contact with the ram during the appropriate period. To achieve this, it is suggested that the breeding of hoggets occurs in smaller, flatter paddocks and not in the same flock as the mature ewes.

Ram to ewe hogget ratio

A number of studies have shown that conception and pregnancy rates improve as the ratio of rams to ewe hoggets decreases from 1:200 to 1:30. (Figure 4). Although lower ratios (i.e. 1:30) can result in slightly higher pregnancy rates, than 1:100, they may not be cost effective. The optimal ewe hogget to mature ram ratio is likely to be the range of 1:70 to 1:100. It is also very important that rams are used in teams, because ewe hoggets are receptive to the ram for a shorten period than mature ewes (i.e. they are on heat for 12 – 24 hours compared to 24 – 36 hours). They are also less willing to stand for the ram. One study showed that only 70% of ewe hoggets which displayed tupp marks (evidence of being mounted) from just one ram had spermatozoa inside their reproductive tract. It was not until they displayed evidence of three separate tupp marks that they all had spermatozoa in their reproductive tract.

Which age class of rams to use?

If extra rams are sourced specifically for hogget breeding, they add costs to the farming system. There are three types of rams that could be used to breed with hoggets; fresh mature rams, mature rams already used in the same season with the mature ewe flock and ram hoggets. Studies have shown that mature rams that have been used for a 17 day period (one reproductive cycle) with the mature ewe flock at a ratio of 1:100 just prior to hogget breeding can be reused with ewe hoggets and achieve the same pregnancy rates as fresh mature rams, which have not been used in that season. Therefore these 'used' rams offer a relatively cheap source of rams in situations where rams are removed from the mature ewe flock after 17 days and replaced with terminal sires. Well grown hogget rams can be used for breeding with ewe hoggets however, these need to be used in teams at ratios of 1:50 or lower. If used at the ratios suggested for mature rams, lower pregnancy rates may be achieved.

Does breed of ram matter?

It is often stated that breed of ram influences the mortality rates of lambs born to hogget ewes. Although, there is a general lack of scientific data to support this. It is considered prudent when selecting rams for breeding with ewe hoggets, that the size of the ram and the shape of his shoulders are taken into account because of potential birth difficulties (dystocia). It is probable that sires from the larger breeds may predispose ewe hoggets to dystocia as their genes influence the growth of the fetus. But again there is a lack of scientific evidence to support this. To avoid the potential effects of breed it has been suggested rams of the same breed as the ewe hogget or of a smaller breed (e.g. Cheviot, Perendale, Southdown) be used. If hoggets are of adequate live weights at breeding and continue to gain live weight at appropriate levels throughout pregnancy, the potential influence of ram breed on dystocia may be of little concern.

Length of joining

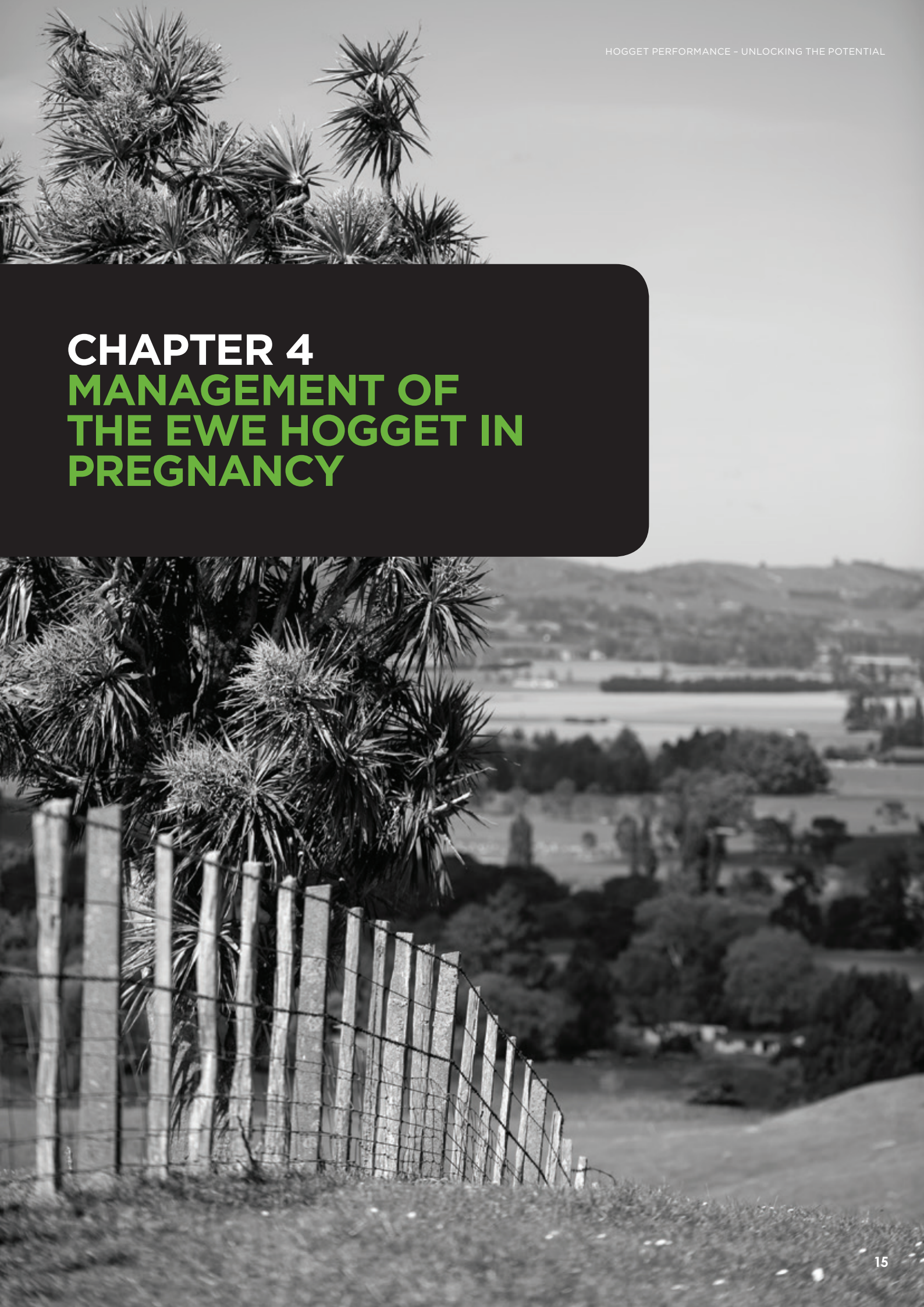
Ewe hoggets are generally bred for one or two reproductive cycles (17 to 34 days). Because ewe hoggets are bred a month or so later than the mature ewes, extending the breeding period beyond 34 days can lead to a long, drawn out lambing period and a "tail end" of late hogget lambs or result in a later than ideal weaning date. Not only will these tail end lambs be difficult to manage, a delayed weaning reduces the time the young dam has to gain live weight before two-tooth breeding. The length of breeding should consider two important points. Firstly, what is the target number of pregnant hoggets and secondly, what is the likely impact of later born lambs. The use of teasers pre-breeding offers a means of reducing the breeding period to just 27 days. This because those that respond to the teaser will display reproductive activity (heat) within 10 days of the entire ram being introduced. Then if they fail to conceive to this mating event they will come on heat again approximately 17 days later. Therefore within a 27 day breeding period there will be two opportunities to get hoggets, which respond to the teaser, pregnant.

Use of crayon harnesses on rams

Crayon harnesses on rams are a good tool to use with ewe hoggets. Those hoggets which do not display crayon marks on their rumps are unlikely to be pregnant. Therefore these can be managed in the post-breeding period as a traditional, non-bred hogget. This will allow feed to be saved for their pregnant counterparts. Farmers should follow the recommended colour pattern and change the colour at least every 17 days.

In addition, harnessed teaser rams could be utilised after the entire rams have been removed from the ewe hoggets (i.e. at the end of the breeding period) to identify hoggets that did not hold to their breeding or that lose their pregnancy early. Again this allows these animals to be removed, saving feed for their pregnant counterparts.

Because the success of hogget breeding relies on ensuring hoggets continue to gain live weight themselves throughout pregnancy, which is in winter when feed levels can be short, there are clear gains to be made from identifying early, via crayon harness marks, those ewe hoggets which require higher levels of feeding. The importantance of feeding levels in the early period of pregnancy will be discussed later. However it is important to recognise that waiting until pregnancy scanning to identify which hoggets would benefit from additional feeding limits the ability of the farmer to manipulate the live weight of the pregnant hogget and to influence her performance and that of her lambs to weaning.



CHAPTER 4
MANAGEMENT OF THE EWE HOGGET IN PREGNANCY

Introduction

The in-lamb ewe hogget flock becomes a priority stock class over the winter period. Feeding levels must not only meet the maintenance and live weight gain requirements of the hogget but also the needs of the developing fetus and mammary gland. Pregnancy is the period when farmers must have appropriate management strategies in place to ensure maximum performance of the ewe hogget and her offspring to weaning and to ensure the young mother is well set up for two-tooth breeding.

The importance of meeting live weight gain targets during pregnancy

The traditional approach to feeding pregnant mature ewes has been to control their intake until approximately the last third of gestation. This is based on the principal that the mature ewe has reached her mature live weight and that the largest nutritional demand for pregnancy occurs in that last third of pregnancy. However the ewe hoggets is in a totally different situation. There are two clear aims for the feeding of hogget ewes in pregnancy firstly, to ensure she successfully weans an adequately sized lamb and secondly, although some might argue most importantly, she needs to continue to gain live weight herself so that her future performance is not impaired. Thus the ewe hogget needs to be gaining live weight throughout the entire pregnancy period. In fact it is important for farmers to realise that during the last third of pregnancy it is very difficult, because of the demand the fetus, for the ewe hogget to actually gain live weight herself. Therefore it is the first two-thirds, or 100 days of pregnancy, that have huge impact on the success of hogget breeding and future two-tooth live weight and performance. This is because it is only in this period that the ewe hogget has any real capacity to continue to gain live weight.

A number of studies examining the effects of live weight gain during pregnancy have noted that weight gains of less than 100 g/d throughout pregnancy (including the pregnancy gains) had a negative impact on the live weight of the ewe hogget and her offspring at weaning in comparison to a hogget gaining 130 – 150 g/d. While there appears to be little improvement in the performance of the hogget or her offspring from gaining above 200 g/d throughout pregnancy, in fact it could be argued that gains above 200 g/d are an inefficient use of feed.

Interestingly pen-feeding trials conducted in the United Kingdom utilising concentrate rations reported that excessive feeding of single bearing ewe hoggets, resulting in gains in excess of 230 g/d (230 – 320 g/d in pregnancy, which includes pregnancy gains) in total weight, increased the risk of lost pregnancies and resulted in lower lamb birth weights and survival rates. It is unlikely that these levels of total weight gains in pregnancy would be achieved under pastoral based grazing conditions during winter in New Zealand. There are only a few New Zealand studies in which hoggets have gained, under experimental pastoral based conditions, in excess of 200 g/d (200 – 240 g/d). Across those studies high gains generally did not had negative consequences. However, farmers should be aware of the potential negative impacts of excessive over-feeding of pregnant ewe hoggets.

Assuming a 4 – 5 kg birth weight of a lamb born to a hogget, the total conceptus mass (placenta, fluids, fetus) will be approximately 9 to 10 kg just prior to lambing. Two-thirds of this gain in weight occurring during the last third of pregnancy (Figure 5). If ewe hogget live weight at breeding is assumed to be 40 kg, with a target live weight of 50 kg the day after she lambs (and a aim of 60 – 65 kg two-tooth breeding weight) then the hogget needs to gain at least 20 kg in total weight throughout pregnancy (10 kg for her own live weight gain and 10 kg for the pregnancy). In this scenario over the entire 147 days of pregnancy the ewe hogget needs to gain total weight at a rate of approximately 130 g/d. Therefore a further advantage of having hoggets as heavy as possible at breeding is that it reduces the amount of gain required in pregnancy. For instance a 45 kg ewe hogget at breeding only needs to gain 15 kg in total weight throughout pregnancy if the aim is still for her to weigh 50 kg the day after lambing (Figure 6). Note for a hogget carrying twins the conceptus mass is likely to be in the order of 12 to 13 kg at term. This indicates the importance of utilising pregnancy scanning to allow for targeted nutrition of multiple bearing hoggets.

The achilles heel of hogget breeding is probably the inability to feed the hogget enough during the entire pregnancy period so that she continues to gain live weight. As mentioned earlier this requires the hogget to be gaining 130 to 150 g/d on average throughout pregnancy. Adjustments need to be made to either feed supply or demand on farm. Reducing the numbers of other classes of stock may be required. It has been suggested that the extra feed demand for 7 – 8 pregnant hoggets, over non-pregnant ones, is equivalent to one mature ewe. Table 4 indicates the average daily requirements for a 40 kg singleton bearing pregnant hogget that gains 100 g/d of her own live weight during the first 100 days of pregnancy and then gains 10 kg in total

Figure 5: Schematic diagram of increases in weight of the fetus, placenta and mammary gland

Source: D Revell

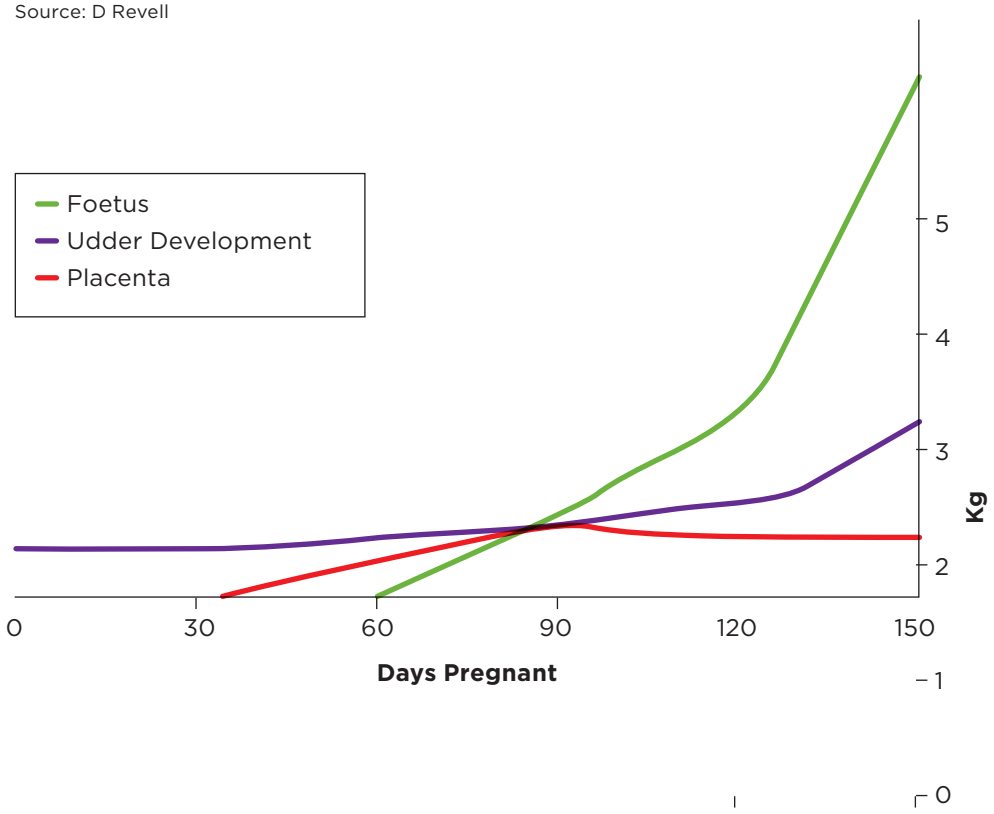
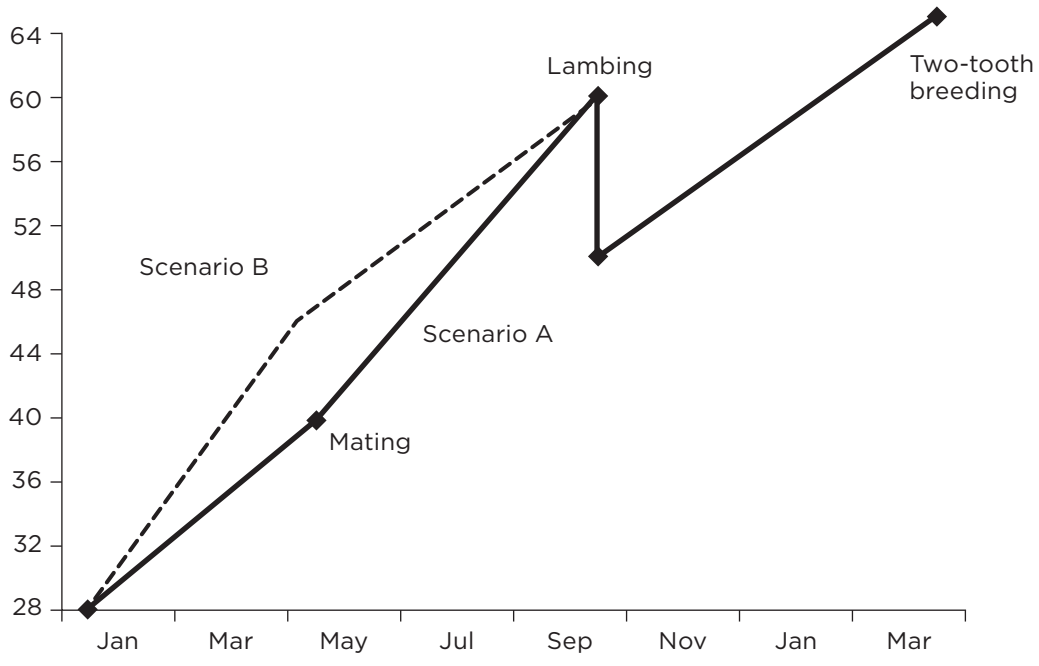


Figure 6: Possible live weight profiles from prior to hogget breeding to two-tooth rebreeding



pregnancy weight over the last third of pregnancy. In this scenario she should weigh approximately 50 kg the day after she lambs. Although this might seem very artificial, it is actually very difficult for the hogget to gain her own live weight in late pregnancy due to the demand and growth of the pregnancy.

If a typical non-pregnant hogget gained live weight at approximately 70 g/d during the late winter/early spring period she would have a daily requirement of approximately 12.5 MJ ME/d when she weighed 40 kg, and approximately 14.1 MJ ME if she weighed 50 kg. This is much less than the scenario in table 4, when a hogget might be 100 – 140 days pregnant, indicating the extra winter demands hogget breeding puts on a farming system. Having the ewe hogget heavier than 40 kg at breeding is an advantage as it puts less pressure on the farming system as this hogget can gain at a lower rate in the winter and still achieve 50 kg the day after she lambs (Figure 6).

To achieve target total live weight gains of approximately 100 to 150 g/d throughout pregnancy hoggets should be managed to ensure ryegrass white clover pasture pre-grazing masses of 1400 kg DM/ha or above, and post grazing masses above 1200 kg DM/ha. For farmers who use sward height as a measure of feed availability this equates to moving the hoggets before the sward height is below 3 cm. Figure 7 indicates that as sward height drops live weight gain is reduced. It is important to note that these pasture mass guidelines are for the entire pregnancy period and the pasture should be of high quality. Various winter crops could be used to ensure hoggets gain at the required levels throughout pregnancy. With these, it is important to ensure intake is not limited (i.e. the hoggets are not forced to consume all of the herbage and/or to graze to low levels) and that the crop is of high quality.

Nutritional studies involving hoggets have shown that it is relatively difficult to manipulate the birth weight of their lambs. For example in studies where hoggets have be managed to gain approximately 80 – 120 g/d (i.e. total live weight gain of 12 to 17 kg) throughout pregnancy, the birth weights of their lambs have been in the order of 3.7 to 4 kg, while hoggets managed to gain approximately 200 g/d (at total live weight gain of near 30 kg) their lamb's birth weight have been in the order of 3.9 to 4.2 kg. This indicates that fetal growth is primarily under genetic control rather than nutritional. It also helps to explain why dystocia is an issue in hoggets. This is because if the hogget is not well grown, the fetus is still somewhat pre-programmed to be within a certain birth weight range. Therefore the poorly grown hogget is likely to suffer from dystocia, regardless of how well she is fed in late pregnancy (i.e. she is relatively smaller in proportion to her lamb's birth size compared with a larger well grown hogget). However, if a hogget is well fed in early – to mid-pregnancy, allowing her to grow (i.e. gaining 130 – 150 g/d), her bone structure and thus the pelvic opening will be larger and she will be more able to successfully give birth to the lamb unaided.

In a farmer survey (Figure 8) lamb losses decreased by around 3% per 1kg hogget weight gain over the range 4 to 10kg. The beneficial effect is likely due to improved placental development, increased ease of birth, improved lamb birth weight and vigour, increased early colostrum and milk production, improved survival and subsequent mothering ability of the ewe hogget.

Live weight targets as an alternative to live weight gains in pregnancy

An alternative to target live weight gains is target live weights at strategic time points during pregnancy (appendix 1). An analysis of a large dataset from a number of studies has shown that live weight of the hogget at breeding, days 50 and 100 of pregnancy and just prior to lambing all have relationships with lamb birth and weaning weight and the live weight of the ewe hogget at weaning (see Table 2). However what is interesting about this table, is that it is the live weight at breeding and at day 50 of pregnancy that have the biggest impact on the performance of ewe hogget and her offspring to weaning. In other words, the heavier the hogget is in early pregnancy the greater the ability the hogget has to cope with the rigours of being pregnant and lactating. This further enforces the importance of a minimum live weight target at breeding and ensuring hoggets continue to gain live weight in early pregnancy. A further point Table 2 illustrates is that hogget live weight, in late pregnancy, has only a very small influence on lamb birth weight, supporting the concept that birth weight is predominately under genetic control. The effect of hogget live weight on lamb birth weight is greater in twin – than single-bearing hoggets. Birth weight of lambs born to hoggets influences their survival chances (Figure 9 and 10).

Pregnancy diagnosis (ultrasound scanning)

Hoggets should be pregnancy diagnosed between days 50 and 80 of pregnancy. Scanning allows the identification and differential feeding of dry, single – and twin-bearing hoggets. Some flocks are now scanning in excess of 25% of hoggets with twins and in this situation separating single and twinning mobs is recommended.

Timing and effect of mid-pregnancy or pre-lamb shearing

Shearing of mature ewes in mid-pregnancy (days 60 to 100) has been reliably shown to increase lamb birth weight and survival to weaning. The response

Table 4: The metabolisable energy requirement per day (MJ ME/d) for a 40 kg ewe hogget gaining 100g/d for the first 100 days or pregnancy followed by pregnancy requirement in late pregnancy.

	Day of pregnancy								
	0	**20**	**40**	**60**	**80**	**100**	**120**	**140**	**147**
Total live weight of hogget including pregnancy (kg)	40.0	42.2	44.4	46.9	49.8	53.2	55.4	58.6	60.0
Pregnancy free live weight gain (kg/d)	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0
MJ ME/d	14.8	15.3	15.8	16.5	17.7	19.7	16.4	20.5	22.3

This is based on a pasture with an ME of 11 and includes an 8% wastage factor (Brookes unpublished).

In this scenario it is assumed the hogget will gain 10 kg of her own live weight in the first 100 days after pregnancy. After this point in time any gain in weight is the weight associated with the gain for the pregnancy only(approximately 10 kg in total weight). It is assumed she will weigh 50 kg after she has given birth to the lamb.

Figure 7: Effect of pasture height on the live weight gain of ewe lambs

Adapted from: During et al. 1980

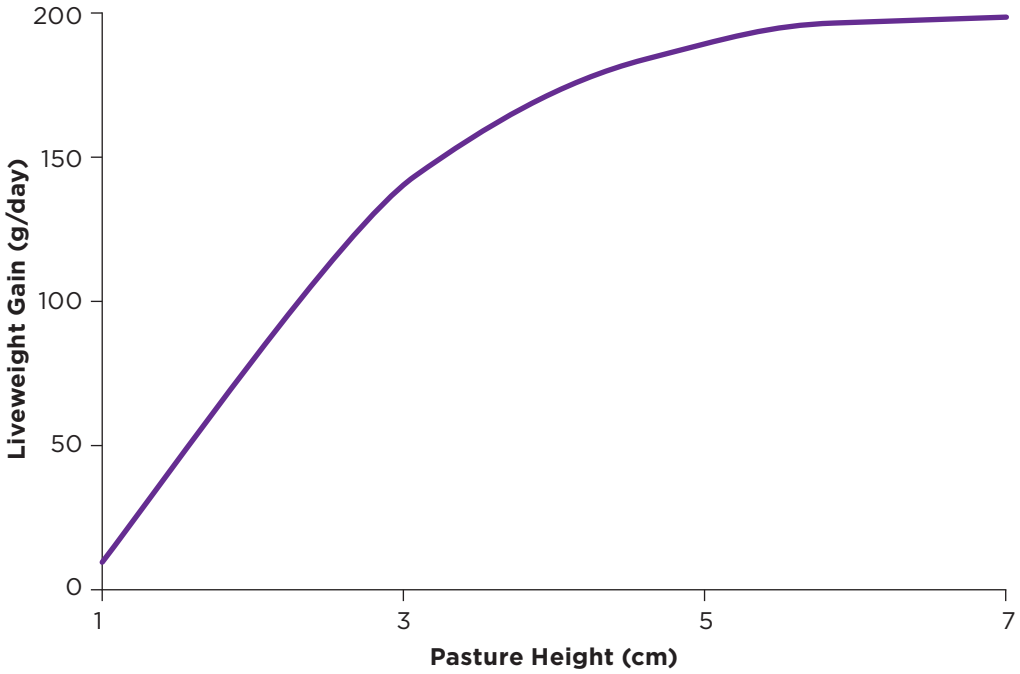


Figure 8: Effect of hogget live weight gain during pregnancy on lamb losses

Adapted from 'A guide to hogget lambing'

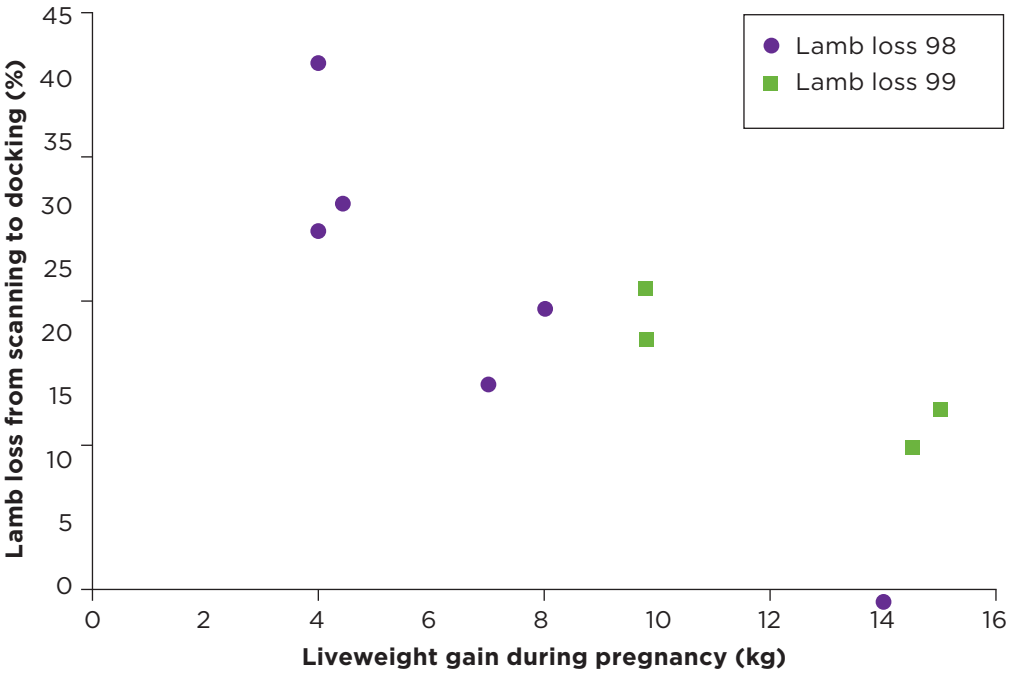
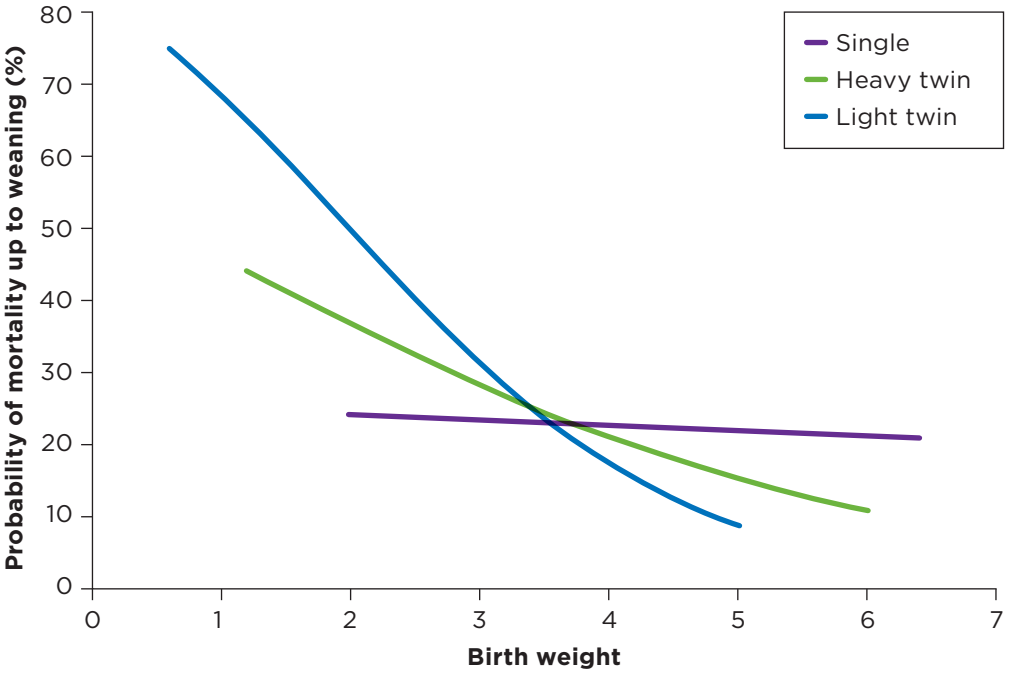


Figure 9: Effect of hogget lamb birth weight on lamb survival to weaning

From: Schreurs et al. 2010b.



has been most consistent in multiple-bearing ewes. In hoggets, the effect of mid-pregnancy shearing has not been intensely studied. However, in one study, it has been shown that mid-pregnancy shearing can increase singleton lamb birth weight but it had no effect on twin lamb birth weight. The increase in birth weight was not associated with a change in lamb survival to weaning. Any means that increases lamb birth weight without altering the size of the hogget may increase the risk of dystocia. In multiple-bearing mature ewes the birth weight response consistently occurs when the ewes are in good body condition and therefore the ewe has the ability to partition 'extra' body reserves to the growing fetuses. It is unlikely that hoggets carrying twins have 'extra' body reserves available to enhance fetal growth.

The survival response from lambs born to mid-pregnancy shorn mature ewes is mainly due to the lamb being larger at birth and being better able to cope with poor weather. While hoggets tend to lamb later than the mature ewe flock, when the weather is generally more settled, which suggests that a survival response from being heavier at birth is less likely in lambs born to hoggets.

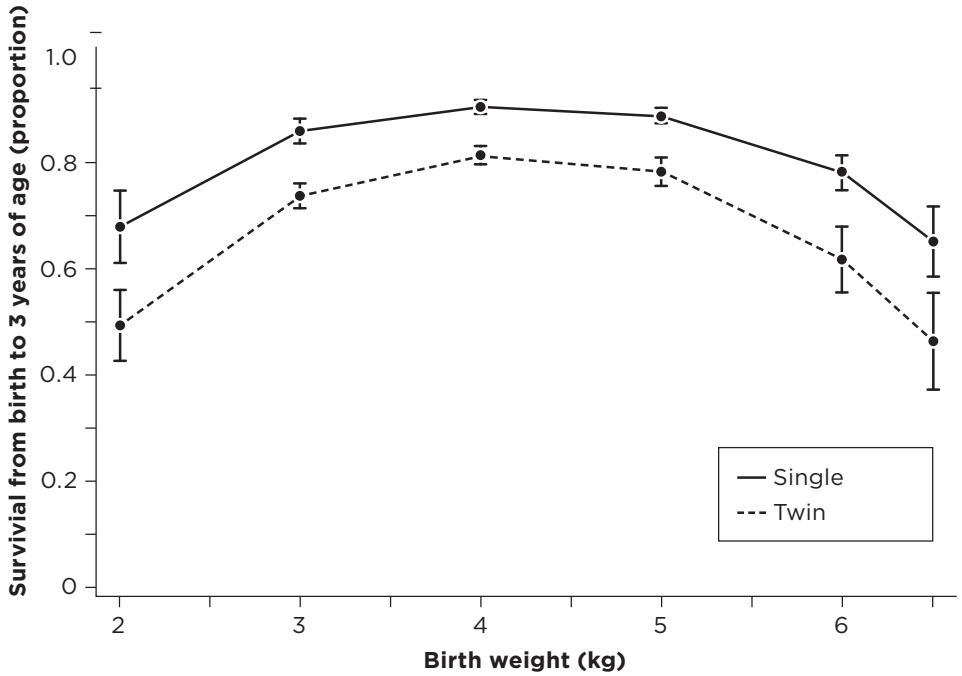
Shearing can also be done much later in pregnancy (during the last third of pregnancy). The concept here is that the ewe with her wool recently removed feels the cold and seeks shelter at lambing. However, ewes shorn in mid-pregnancy will have grown enough fleece by lambing that they will not feel the cold. Late pregnancy shearing should ideally be no later than four weeks prior to the commencement of lambing.

Shearing in both mid – and late-pregnancy increases heat loss from ewe hoggets and may stimulate appetite, although this has not always been reported and when found, has generally been less than a 10 % increase. Sheep shorn during winter must be protected from exposure. Depending on the region, genuine winter combs, winter combs plus lifters, or blades should leave sufficient wool for protection from all except the worst weather. The time removed from pasture should be limited. After shearing, pregnant hoggets should be placed in sheltered paddocks with adequate feed (pasture covers above 1200 kg DM/ha). Shelter is essential to prevent cold stress, especially in adverse weather. Wind and rain increases heat loss and in extreme conditions can cause death due to exposure. Farmers should monitor the weather forecast. They may also wish to consider stopping shearing earlier in the day, as hoggets shorn late in the day will have had a longer period off feed and when it is dark, they may be less inclined to graze.

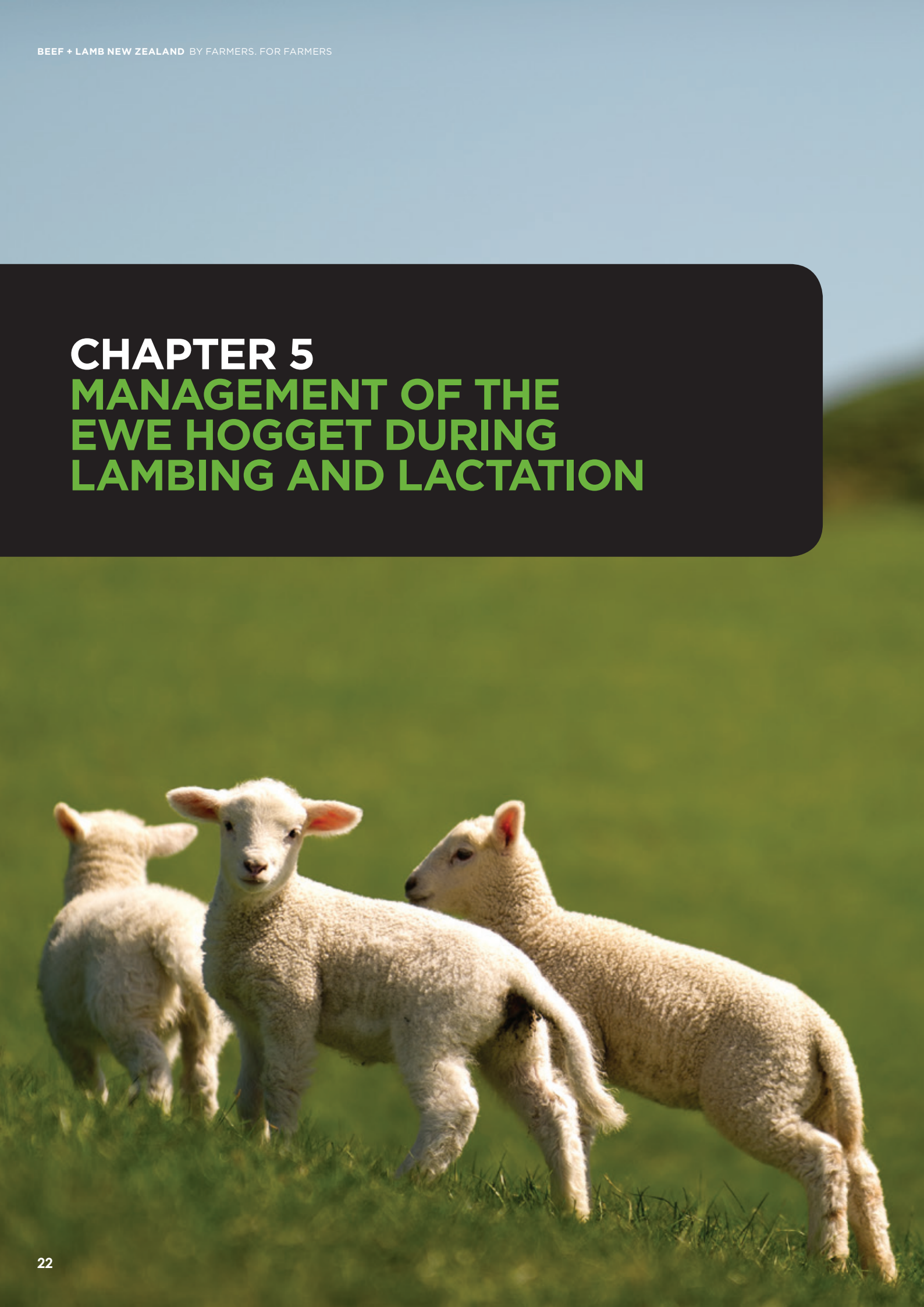
Animal health management

Farmers should, in conjunction with their veterinarian develop an animal health plan for the ewe hogget in late pregnancy and lactation. Ewe hoggets need to have the course of pre-lamb vaccinations.

Figure 10: Regression of Survival from birth to 3 days of age (SurvJ3, proportion) on lamb birth weight (BWT, kg) for singles and twins.
From: Adapted from Young et al. 2010



CHAPTER 5
MANAGEMENT OF THE EWE HOGGET DURING LAMBING AND LACTATION



Introduction

Once lambs are born to ewe hoggets, it is important to grow them as quickly as possible and to continue to ensure the hogget herself is still gaining live weight. Lambs born to hoggets tend to be lighter at weaning and are generally weaned later in the season than lambs born to mature ewes. Therefore it is important that these lambs grow to their potential.

Set stocking

As with mature ewes, it has been shown that set stocking single – and multiple-bearing hoggets separately increases lamb survival to weaning. Twin-bearing ewe hoggets should be offered the most sheltered paddocks, and at a lower stocking rate. A lower stocking rate has two potential advantages; firstly it lessens the chance of mismothering and secondly it allows for more feed available per twin bearing hogget. Paddocks with a slope of greater than 30 degrees should be avoided. To ensure ewe hogget and lamb performance is not limited, the hogget and her offspring need to be offered high quality pasture with herbage masses not falling below 1200kg DM/ha.

Lambing beats

Hoggets are more susceptible to dystocia than mature ewes due to their smaller body frame size. Therefore farmers may wish to consider some form of lambing supervision (lambing beats). However, if this is to be attempted, the hoggets must be accustomed to the presence of the farmer.

Feeding lactating hoggets

As indicated earlier, if a single-bearing hogget weighs approximately 60 kg the day before she lambs she will weigh around 50 kg the day after. If we assume the hogget lambed on the 1 October and two-tooth breeding is on 1 April, with a target live weight of 65 kg she needs to gain approximately 85 g/d during that period. The hogget should also lactate at her potential so that her lambs firstly survive and secondly are as heavy as possible at weaning. Further, depending on the location of the farm the hogget may face a dry summer/autumn period prior to re-breeding. Combined, these points indicate the importance of ensuring the hoggets intake is not limited in lactation. Theoretical requirements are stated in table 5.

Ewe hoggets should lamb and lactate in paddocks where pasture covers do not fall below 1200 kg DM/ha. This should maximise hogget intakes and ensure optimal live weight gain of both the ewe hogget and its lamb(s). Pasture quality can also have a significant impact on hogget growth, lactational performance and the growth of their lambs. Pasture quality declines as spring advances and grasses begin to produce stem and seedhead. Therefore pasture covers should not be allowed to get above 1800 kg DM/ha. This further indicates the importance of appropriate stocking rates. Farmers should monitor pasture covers and once the lambs are mobile and the period of potential lamb mismothering is over be prepared to move the hogget and her lamb(s) to ensure the pasture masses are within the optimum (1200 – 1800 kgDM/ha).

Table 5: The metabolisable energy requirement per day (MJ ME/d) for a 50 kg ewe hogget rearing a singleton lamb (including requirements for the lamb) in lactation.

Note: One ewe is not changing live weight (Part A) while the second ewe is also gaining live weight herself at a rate of 85/g (Part B).

	Approximate weeks since lambing					
	1	3	5	8	10	12
Part A (0g/d)						
Ewe requirements	21.6	22.6	22.5	21.9	20.8	18.9
Lamb requirements	0.0	0.5	1.5	2.8	4.6	6.8
Total requirements	21.6	23.1	24.0	24.7	25.4	25.7
Part B (85g/d)						
Ewe requirements	25.6	26.7	27.0	26.6	25.7	24.1
Lamb requirements	0.0	0.5	1.5	2.8	4.6	6.8
Total requirements	25.6	27.2	28.5	29.4	30.3	30.9

This is based on a pasture with an ME of 11 and includes an 8% wastage factor (Brookes unpublished). The values include the maintenance requirements of the ewe hogget. The lamb is assumed to weigh 23 kg at weaning.

CHAPTER 6
WEANING AND POST-WEANING MANAGEMENT OF EWE HOGGETS AND THEIR LAMBS

Introduction

Lambs born to ewe hoggets are on average 1 to 1.5 kg lighter at birth than those born to mature ewes and approximately 3 – 5 kg lighter at weaning. However because lambs born to ewe hoggets are generally born a month later than those born to mature ewes, at a given date they can be even lighter. This lighter lamb live weight influences when weaning should occur. There is some debate as to whether hoggets should be weaned on a given date, at a certain age, or at a target weaning live weight. While circumstances differ from farm to farm, and region to region, there are many factors to consider when deciding when to wean.

When to wean hogget lambs?

While it may be beneficial for the lamb if it is weaned as late as possible, late weaning limits the time the young dam has to gain live weight before two-tooth breeding. Unlike mature ewes, it is unlikely that many lambs will be weaned directly to slaughter. Therefore the vast majority of the lambs born to hoggets will be either sold store or require finishing on farm. Given this, the aim should be to time weaning to ensure that the lamb is in the best possible position to continue to grow post weaning, while still ensuring the young dam has enough time to achieve a suitable two-tooth breeding live weight.

Lambs born to hoggets can be successfully weaned at 9 – 10 weeks, at a live weight of 20 kg. To ensure adequate weaned lamb live weight gains, lambs should be offered high quality pasture with a herbage mass of at least 1200 kg DM/ha (4 cm sward height, allowance above 3 kg DM/day (Figure 2 and 7). An ideal pasture should be clover-dominant and the grasses should be mainly new green leaf, with little stem or dead leaf material. Such pastures have an ME value of 11-12 MJ ME/kgDM (Figure 3). Pasture masses above 1800 kg DM/ha should be avoided as pasture quality will have begun to decline. Alternatively forage crops could be utilised. Forages such as chicory, red clover, birdsfoot trefoil, sulla, or summer brassicas such as pasja or rape, can all provide high quality feed with ME values in the 11 – 12 range. It has been shown that lambs born to mature ewes can be successfully weaned at live weights of only 16 kg although, lambs at such low live weights can be fragile.

Managing ewe hoggets post weaning

Hoggets which wean a lamb(s) are generally lighter than their counterparts which were either not bred or which failed to rear a lamb. If hogget breeding results in light weight two tooths it will affect the overall productivity achieved from hogget breeding. Therefore after the weaning of their lambs, a sub-sample of the hoggets (at least 50) should be weighed. This information coupled with target two-tooth breeding live weights enables farmers to plan for the level of live weight gains required before re-breeding. To ensure live weight gains are not limited, pasture masses should not fall below 1200 kg DM/ha (4 cm sward height) or be above 1800 kg DM/ha. Post-weaning, monthly weighing (of a sub sample) will allow the progress of the young ewe to be monitored. It is easier to address below target live weights the earlier they are identified. As with their weaned lambs, forage crops can be utilised to ensure target live weight gains are met. Table 6 indicates intake requirements for a hogget post weaning either maintaining or gaining live weight.

Animal health requirements of weaned hoggets

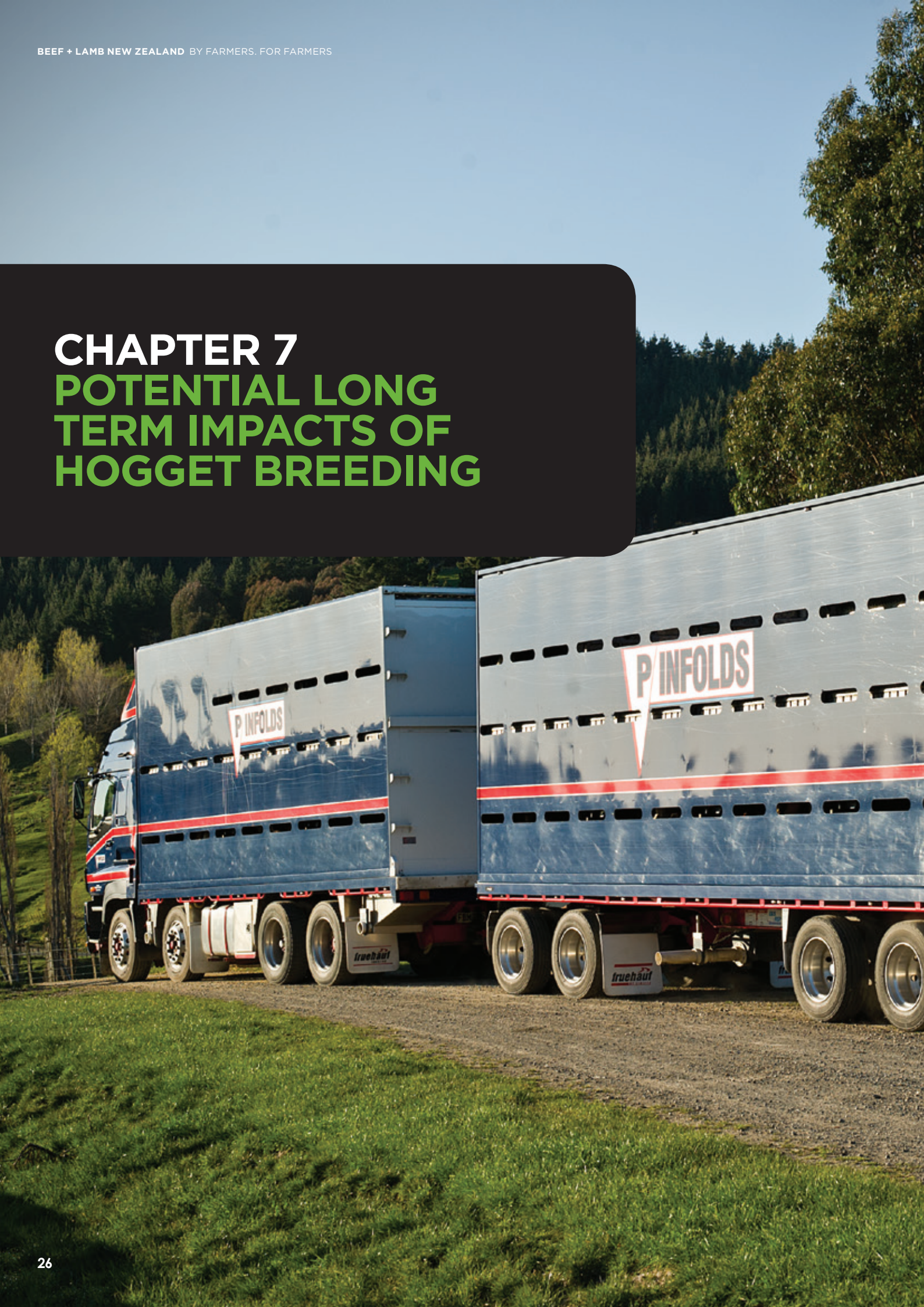
To ensure hoggets gain live weight at relatively high rates they need to be free of animal health problems. Therefore post weaning an animal health monitoring and management plan should be in place following consultation with the local veterinarian.

Table 6: The metabolisable energy requirement per day (MJ ME/d) for ewe hoggets post weaning and prior to two-tooth breeding.

Live weight gain / day (g)	Live weight (kg)					
	42	**46**	**50**	**54**	**58**	**62**
0	8.5	9.3	10.0	10.7	11.5	12.2
50	11.7	12.6	13.5	14.4	15.2	16.0
100	15.0	16.0	17.1	18.0	18.9	19.8
150	18.2	19.5	20.6	21.7	22.6	23.6
200	21.5	22.9	24.2	25.3	26.4	27.4
250	24.9	26.4	27.8	29.0	30.2	31.2

This is based on a pasture with an ME of 11 and includes an 8% wastage factor (Brookes unpublished).

CHAPTER 7
POTENTIAL LONG TERM IMPACTS OF HOGGET BREEDING



Introduction

The potential long term advantages from successfully breeding ewe hoggets include; an early selection/screening tool, an increase in lifetime performance and a potential reduction in the generation interval if progeny born to ewe hoggets are selected as replacements. There are also some potential long term disadvantages which are of concern to many farmers. These include; the potential for reduced two tooth live weight and reproductive performance and decreased longevity within the flock.

Early selection of ewe replacements

It has been shown that ewe hoggets which are presented for breeding but fail to get pregnant are heavier at two tooth breeding than those which do lamb as a hogget. But the reproductive performance of the former as a two tooth is no better and in some cases worse than the latter. Some studies have shown that the performance of ewes that did not get in lamb as a hogget, is slightly poorer. It is known that two-tooth fertility is genetically correlated with the occurrence of puberty as a hogget. This information suggests that ewe hogget breeding could be an early screening tool for poorer performing ewes and farmers may wish to cull ewe hoggets, if they were of suitable live weight at hogget breeding, but failed to get pregnant. A possible management option for farmers is to present more hoggets for breeding than they require as replacements ewes and cull those which fail to get pregnant.

Increased in lifetime performance

The lifetime reproductive performance of ewes which lambed as a hogget is greater than those which did not lamb as a hogget. However, the size of this benefit is very much dependant on the success rate of hogget breeding and any negative impact on two tooth reproductive performance. Both live weight and nutrition of the ewe hogget have the biggest influence on its performance as a hogget and as a two tooth. Therefore, if farmers wish to maximise the potential lifetime benefit from hogget breeding, they need to ensure that target hogget live weights are met pre-breeding, during pregnancy and post-weaning and at two tooth breeding.

Reduction in the generation interval from selecting replacements born to ewe hoggets

Many farmers suggest that a means of improving genetic progress within their flock is to select replacements born to ewe hoggets and therefore reduce the generation interval. However, very few farmers actually do this. There is little data on the performance of progeny born to ewe hoggets in comparison to those born to mature ewes, when both groups of ewes have been bred at the same time to the same rams, thereby removing any potential benefit of the lambs born to mature ewes being older. Singleton lambs born to hoggets are generally lighter until 8 – 12 months of age compared to those born to mature ewes when most studies have shown that they have 'caught up'. In fact, comparisons of the productive performance of singletons born to either ewe hoggets or mature ewes have shown they do not differ. However, the small amount of data available on twins born to hoggets indicates that they are still lighter to at least 18 months of age, with studies under way to determine if there is a permanent effect on performance.

The potential for reduced two tooth live weight and performance

An often stated, concern about hogget breeding is the potential for negative effects on two tooth live weight and performance. Indeed some studies have shown that breeding ewe hoggets can reduce two-tooth breeding live weight by up to 6 kg. However, this live weight effect has had either no effect or only a minor negative effect on two tooth reproductive performance. Conversely, many studies have shown a positive effect of hogget breeding on two tooth performance. Across studies, it is apparent that when there is no effect of hogget breeding on two tooth live weight there can either be no impact or a positive impact of hogget breeding on two tooth performance. Therefore farmers need to ensure target hogget live weights are met if the full benefit from hogget breeding is to be achieved.

Any reduction in two tooth live weight from hogget breeding has generally been found to disappear by the weaning of their second set of lambs, it is not a permanent stunting, contrasting to a statement often made by farmers.

The potential for decreased longevity and productivity in the flock

A commonly heard concern among farmers is that breeding as a ewe hogget reduces longevity. However a number of studies have shown that this is not the case in flocks were ewes have been kept to six years of age. It is possible that if hogget breeding had a large negative impact on two tooth breeding live weight, a greater percentage of barren two tooths might be observed and thus greater culling rates could occur. This again points to the importance of meeting those hogget live weight targets pre-breeding, during pregnancy and post weaning.

APPENDIX I
POTENTIAL TIMETABLE FOR EWE HOGGET BREEDING

Below is an outline of a management plan for hogget breeding. In this timetable it has been assumed that the ewe lamb was born on 1 September and then weaned on 1 January at 30 kg. The ewe hogget is then presented for breeding on 1 May weighing 42 kg. She is re-bred as a two-tooth weighing 62 kg.

Month of year	Age (months)	Target weight (kg) at 1st of the month	Tasks for month
January	5	30	Shearing, clostridial vaccination
February	6	33	Second clostridial vaccination
March	7	36	Campylobacteriosis vaccination Toxoplasmosis vaccination
April	8	39	Second Campylobacteriosis vaccination Teasers introduced 14 April. Teasers in teams at a ratio of ratio 1:70
May	9	42	Ram in 1 May. Rams in teams at a ratio of 1:70. Ram in for maximum 34 days. Rams should have crayon harnesses.
June	10	45	Remove those with no harness marks on rumps
July	11	48	Pregnancy diagnosis. Remove non pregnant hoggets
August	12	52	If mid-pregnancy shearing this should be done early in the month. Cover comb or snow should be used.
September	13	56	Note they should weigh 60 kg the day before they lamb. Pre-lamb vaccination in early September Set stock two weeks pre-lambing at a rate in which covers will no drop below 1200 kg DM/ha or a sward height of 4 cm. Twin bearing hoggets should be offered paddocks with more shelter and that are not too steep.
October	14	50	
November	15	52	Docking, remove wet/dry hoggets, weigh and condition score a subset of hoggets
December	16	54	
January	17	56	Wean in early January to give time for young ewe to recover. Shear ewe post weaning. Weigh and condition score a sub set post shearing
February	18	58	Campylobacteriosis vaccination
March	19	60	
April	20	62	Re-breed

APPENDIX II
SUMMARY OF ASPECTS OF THE LITERATURE ON EWE HOGGET REPRODUCTION.

Comparison of reproduction of mature ewes and hogget

Quirke & Hanrahan (1977), Beck et al. (1996) and Mulvaney (2011) all reported that ovulation rate was lower in ewe hoggets than mature ewes. Hogget fertility and conception rates have also been reported to be lower than for mature ewes (Keane 1976; McMillan & Kitney 1983; Smith & Knight 1998). McMillan & McDonald (1985) reported that ewe hogget ova were less viable. They suggested that this was a major reason for lower fertility in ewe hoggets. Similarly, Quirke & Hanrahan (1977) reported ewe hogget ova had a lower capacity for survival than ova from mature ewes. In addition, Mulvaney (2011) reported that when ewe hoggets and mature ewes were bred together, ewe hoggets were less likely to be mated that mature ewes.

Beck et al. (1996) reported ewe hoggets had increased rates of late (days 15 to 30) embryonic loss compared to mature ewes and Mulvaney (2011) reported greater pregnancy losses to day 69 of pregnancy. Lambs born to ewe hoggets are lighter at birth and weaning than those born to mature ewes (Mulvaney 2011). Further, lambs born to ewe hoggets displays poorer bonding behaviour and the young dam herself exhibits poorer mothering ability (Mulvaney 2011). Combined, these reports help explain why performance is lower in ewe hoggets than in mature ewes.

Timing of the breeding season and puberty

The reproductive activity of the ewe hogget is dependent on the breeding season, and it must reach puberty before it can be successfully bred. The onset of breeding in hoggets is later than that of two-tooth or adult ewes and the breeding season is shorter (Dyrmundsson 1973; Smith & Knight 1998). In New Zealand the peak reproductive activity of ewe hoggets does not occur until the mid-May to mid-June period, with only a small proportion of ewe hoggets reaching puberty and therefore oestrus (heat) before mid-April (Lewis 1959; Smith & Knight, 1998). There are breed differences in the timing of reproductive activity (onset of puberty) with Finnish Landrace showing oestrus earlier in the year. Muir (2001) found with crossbred hoggets that the mean number of oestrous cycles (range in brackets) per hogget for East Friesian, Finn, Poll Dorset crosses and Romneys were 5.0(2-8), 5.0 (2-8), 3.4(0-5) and 3.1 (0-6), respectively; with mean season lengths (days) of 101 (21 April – 3 August), 105 (24 April – 3 August), 72 (3 May – 13 July) and 58 (9 May – 6 July), respectively.

Ovulation rate in ewe hoggets do not to differ between the first, second and third reproductive cycles (Hare & Bryant 1985). However, there will be fewer viable embryos in ewe hoggets mated at the first cycle than for those mated at the second or third (Hare & Bryant, 1985). Overall Hare & Bryant (1985) reported that fertility increased by approximately 20% when breeding occurred at the second rather than first oestrus (heat). Similarly, Beck & Davies (1994) reported that fertility improved to the third oestrus (heat). The stage of the breeding season has been shown to affect hogget ovarian activity, non-return rate and lambing rate (Zain & Mousa 1999).

There are a number of techniques that may be used to advance the breeding season and/or induce puberty. These include; the use of progestagen sponges or CIDR®s followed by hormone therapy; and use of Regulin® (melatonin) implants (Smith & Knight 1998; Gordon 1999). However, the cost, their reliability and the extra management required for the use of these treatments make them unusable for most pastoral based farming situations.

Management to ensure high performance levels

Breeding behaviour of ewe hoggets

Ewe hoggets are 'shy' breeders, they are less likely to seek out the ram and to stand for him (Dyrmundsson 1981, Smith & Knight 1998) and have shorter less intense oestrus (heat) periods (McMillan & Parker 1981, Schick 2001). Keane (1976) found that the sexual behaviour of hoggets was different from mature ewes and reported that rams had more difficulty breeding with ewe hoggets. They noted that although rams mounted the ewe hoggets they actually often failed to mate successfully with them. Edey et al. (1978) also reported poor breeding

behaviour in ewe hoggets compared to mature ewes and reported that they were only in oestrus (heat) for 18 hours compared to 29 hours in mature ewes. Similarly, Allison et al. (1975) found that failure of males to actually get semen inside the hoggets reproductive track was an issue until the ewe hogget had been mounted by at least three rams at one oestrus (heat) event. Keane (1976) reported higher breeding performance in ewe hoggets when kept separately from mature ewes. For this reason, ewe hoggets should not be bred in the same mob with mature ewes for breeding, as the results of Mulvaney (2011) indicate. Quirke (1981) and Edey et al. (1977) both reported that oestrus (heat) without ovulation can be common in hoggets around the time of puberty. Such an occurrence would result in a failure of the hogget to become pregnant to that oestrus (heat) event.

Genetic influences on reproductive performance as a ewe hogget

A number of genetic parameters affecting puberty and first oestrus have been examined. Selection for date of lambing (Smith et al., 1995) has a significant effect on date of first hogget oestrus, and has been suggested as a screening aid in the selection process. Fertility of two-year old Romney ewes has been shown to be genetically correlated with hogget oestrus (Chang and Rae, 1972) which itself is under genetic control (Chang & Rae, 1970).

Breeds, crossbreds and strains within a breed can all differ in the timing of puberty and the proportions displaying hogget oestrus at different periods and weights (Allison et al., 1975; Hight & Jury 1976; Meyer & French 1979; Craig 1982; McMillan & Moore 1983; Moore et al., 1983, 1989; Baker et al., 1985; Muir et al., 2001).

Moore et al. (1984) reported a four year average for lambs weaned per hogget joined of 32 %, 55 % and 50 % for Romney, Coopworth and Perendale hoggets with an average live weights at breeding of 32 kg. Moore et al. (1983) report similar trends, with the Romney being the poorest of the three breeds. McMillan & McDonald (1983) reported no overall difference in reproductive rate between Border Leicester x Romney hoggets and purebred Romneys with an average joining weight of 36 kg. Moore et al. (1989) found strain differences in hogget reproductive performance between Romneys including Booroola Romneys.

Kenyon et al. (2004) in a survey, reported that as the percentage of Finnish Landrace and East Friesian genetics increased within a composite hogget, so did the lambing percentage. They also reported that the only traditional breed to differ from the Romney in hogget lambing percentage was the Coopworth. McMillan et al. (1988) also reported higher reproductive rate of Finnish Landrace and Finnish Landrace crossbred hoggets. In their trial however, hoggets were bred after hormonal treatment. Similarly, Muir (2001) and Stevens (2001a, 2001b) reported higher reproductive performance with Finnish Landrace and East Friesian crosses. It is probable that the higher reproductive performance of Finnish Landrace composites is due to their ability to achieve puberty and display oestrus (heat) at relatively lighter live weights and earlier in the season.

The number of oestrus cycles during a hogget's first breeding season is heritable, so some progress could be made selecting for this parameter. Baker et al. (1979) with Romneys reported a h2 (heritability) value of 0.31 for this.

Ram effect (teasing)

The ram effect is an accepted method for advancing the breeding season in mature ewes just prior to the natural onset of the breeding season (Smith & Knight 1998). Following the introduction of rams a proportion of the ewes ovulate within 40-65 hours, without coming into oestrus. This is a so-called "silent heat" or "silent ovulation". The first oestrus with ovulation occurs 16-17 days after the first or second "silent heat", i.e. 17 to 26 days after ram introduction.

Numerous studies have shown that exposing ewe hoggets to vasectomised rams (teasers) for 17 days in mid-April can increase overall pregnancy rates and can advance the mean breeding date (Kenyon et al., 2005, 2006ab, 2008c). It has also on occasion increased the number of twin pregnancies (Kenyon et al., 2006b). It appears the optimal vasectomised ram to ewe hogget ratio is the range of 1:70-100 (Kenyon et al., 2007a). Use of the teaser before the normal start of breeding (i.e. using the teasers March/ early April) to allow for an early/mid-April breeding has met with some success, although it may not be as effective in terms of a compact breeding as a teasing in mid-April (Cave et al., 2012). Recent data (Kenyon unpublished) suggests that the teasing response might be greater in hoggets fed to appetite rather than in those under controlled grazing conditions.

The use of short-scrotum ram lambs as teasers or exposure to entire rams for just a few days prior to breeding are less effective alternatives to using a traditional vasectomised males for 17 days (Kenyon et al., 2008a, 2008c).

Live weight and growth influences on reproductive performance as a hogget

Environmental effects, especially the effect of year or season can have a large influence on the proportion of hoggets showing oestrus (Moore et al., 1983). Any factor which affects the growth of the ewe lamb/hogget can influence whether puberty is reached in her first autumn. Birth and rearing rank and age of dam has had little effect in some studies (Baker et al., 1979), but not all. It has been reported

that early born lambs attain puberty at older ages and heavier weights than late born lambs, while some late born lambs may fail to attain puberty altogether prior to their first winter (Dyrmundsson 1973; Smith et al., 1995).

Heavier ewe hoggets clearly have a better chance of reaching puberty and displaying oestrus (Dyrmundsson 1973; Winn & Cumberland 1974; Meyer & French 1979; McMillan & Moore 1983) and an adequate level of nutrition has the potential to compensate for a later birth date (Moore & Smeaton 1980). Many studies have shown a positive relationship between live weight of the hogget at breeding and her reproductive performance (Dyrmundsson 1973, 1981; Allison et al., 1975; Hight & Jury 1976; Keane 1976; Moore et al., 1978; Meyer & French 1979; Moore and Smeaton 1980; Meyer, 1981; McMillan & Moore 1983; Gaskins et al., 2005; Kenyon et al., 2005, 2006a, 2009, 2010) In summary, studies show that while hoggets have the capability to be bred at live weights in the low thirties, high reproductive performance is not achieved until hoggets weigh at least 40 kg at breeding.

McMillan & Moore (1983) in an analysis across nine flocks showed that joining live weight differences accounted for 60% and 71% of the between-flock differences in lambs born per hogget joined and hogget bred per hogget presented for breeding. They also reported a regression coefficient of 3.5 lambs born per hogget joined per kg increase in joining live weight. Stevens & McIntyre (1999) reported that conception rate and lambing percentage were not related to breeding liveweight over a 40-51 kg range; whereas Stevens (2001) found that conception rate increased by 2% per kg live weight increase in the 38-53 kg range.

Feeding regimen and growth profile from pre-weaning as a lamb until breeding as a hogget has the potential to affect hogget oestrus and reproduction, although some of this effect is likely due to differences in live weight at breeding (McMillan & Wilson 1983; Moore at al., 1978; Moore & Smeaton 1980; Moore & Miller 1982; Gaskins et al,. 2005). McCall (1978) reported that for hoggets born to ewes aged 1, 2 or 3 years respectively, hoggets lambing per 100 hoggets exposed to the ram was greater as ewes aged. These results may reflect differences in the milk production of the dams and hence early growth rates of the lambs. Hogget live weight data were not presented. Increased nutrition in the period just prior to breeding has been reported to increase the number of fetuses per hogget at pregnancy diagnosis (Mulvaney 2011).

McMillan & Moore (1983), who both worked widely in this area of research, reviewed the effects of level of nutrition on hogget oestrus and summarised the effects as follows:

> "The post weaning growth path of ewe lambs can have a profound effect on the hogget sexual season. Firstly, heavier hoggets within a flock are more likely to attain first oestrus – for every 1 kg increase in autumn live weight about 6% more hoggets will exhibit oestrus. Secondly, the greater the autumn live weight gain the greater the chance of hogget oestrus at the same final live weight – this effect is analogous to the 'dynamic' effect in flushing. Thirdly, at the same autumn live weight hoggets from well-reared flocks will have a greater chance of showing hogget oestrus than hoggets from poorly reared flocks. This outcome can be exploited within a flock by rearing all hoggets well or preferentially feeding the lighter lambs at weaning to achieve greater post-weaning gains. Younger hoggets (i.e. later born) are less likely to exhibit oestrus only when these are poorly reared. However; under improved rearing conditions age of hogget (i.e. birth date) has no effect on hogget oestrus activity."

Body condition score influences on reproductive performance as a hogget

Stephenson et al. (1980) in a breed comparison of body composition found an association between autumn rate of increase in the proportion of body fat and the percentage of ewe hoggets bred. Body condition score is a subjective measure of soft tissue, predominantly fat in the lumbar region. It has been reported that ewe hoggets should be a minimum of body condition score 2.5 at breeding, if high rates of reproductive performance are to be achieved (Kenyon et al., 2009, 2010).

Effect of shearing pre-breeding on hogget lambing performance

Shearing can lead to increased heat loss and potentially a stimulation of appetite (Elvidge & Coop 1974). If ample quality feed is available, live weight gain might occur, but if feed is limiting, the increased maintenance costs, especially if it is cold, could exceed the increased intake and result in live weight loss.

McMillan & Knight (1982) with two-tooths concluded that shearing should occur at least four weeks before breeding if lamb production is to be maximised. This subject has been less intensively studied in ewe hoggets. In hoggets, McMillan & Wilson (1982) found that shearing of ewe hoggets four or two weeks prior to joining had no effect on the percentage of hoggets mated. But in a later study they found that for hoggets shorn either four or two weeks or not shorn prior to joining, the number of hoggets lambing to first mating was greatest in those shorn four weeks prior to breeding (McMillan & Wilson, 1983). Sumner et al. (1982) reported that shearing hoggets pre-mating decreased non-pregnancy rates in one of four studies. Kenyon et al. (2004b) reported that shearing ewe hoggets pre-breeding increases the lambing percentage in comparison to those either shorn well before breeding or those not

shorn at all (Kenyon et al., 2004b). Combined these studies indicate that ewe hoggets should be shorn at least four week prior to breeding.

Shearing immediately post breeding might be an issue. Stevens (2001) reported on one farm that shearing hoggets 12 days after the ram was withdrawn seemed to cause an abnormally poor result. This might have been caused by the stress of the shearing event (Knight et al., 1982).

Nutrition around the breeding period and its effect on conception rates

Indoor studies in the UK (Wallace et al., 1996, 1997a, 1997b) using concentrate feeds have reported that very high levels of nutrition (resulting in live weight gains of at least 230 g/day) reduced conception rates. A few studies examining the effects of nutrition around the breeding period have been undertaken in New Zealand. Kenyon et al. (2008b) compared ewe hoggets with live weight gains of 134 and 223 g/day respectively. A greater proportion of the higher live weight gain hoggets returned to service. However, pregnancy scanning data and the percentage of hoggets which subsequently lambed did not differ. Mulvaney et al. (2010b) compared ewe hoggets with live weight gains of 208 g/d and 153 g/day. The former had a greater percentage of hoggets returning to breeding in the second cycle, although overall pregnancy rates were not affected. Mulvaney et al. (2010a) reported conflicting results of nutrition around pregnancy on return rates. In one study, they reported no effect and in the other reported a negative effect of high live weight gains. But in support of previous studies, overall pregnancy rates did not differ. Overall New Zealand studies indicate that there is the potential for high live weight gains around the breeding period to negatively affect conception rates. However because the high live weight gains result in more hoggets bred, the total overall pregnancy performance is not negatively affected. It has previously been reported in mature ewes that high live weight gains around the breeding period can reduce progesterone concentrations leading to reduced embryonic survival (Parr et al., 1987).

Management of rams during the breeding period.

Allison et al. (1975) report that in one of two experiments, increasing the number of rams from two to four per 220 hoggets increased the number of hoggets mated and conceiving early in the mating period. The survey data of Stevens & McIntyre (1999) suggested a trend of lower hogget conception rates when mob size was larger. They also found as ewe hogget:ram ratio increased from around 50 to 200, conception rate declined from above 80% to below 40%. Smith & Knight (1998) suggested a ram to ewe hogget ratio of 1:50 or lower. Recent studies have suggested the optimal mature ram to ewe hogget ratio is likely to be slightly higher at approximately 1:75 (Kenyon et al., 2004b, 2010).

Ram lambs can be used with ewe lambs for breeding but, if used at the same ratios as mature rams reproductive performance is lower (Kenyon et al., 2007b). Therefore if rams lambs are to be used it is likely that ratios of 1:50 or less are required. Two-tooth ram performance has been shown not to differ from that of mature rams when bred with ewe hoggets at the same ratio (Kenyon et al., 2007b). It has also been shown that the performance of mature rams previously used earlier in the breeding season with mature ewes does not differ from that of 'fresh' mature rams being used for the first time in that season (Kenyon et al., 2009).

The effect of hogget feeding during early and mid-pregnancy

A series of indoor studies in the UK with ewe hoggets (Wallace et al., 1996, 1997a, 1997b, 2000, 2002ab, 2003, 2006b; Da Silva et al., 2003) using concentrate feeds have reported that very high levels of nutrition, resulting in live weight gains of at least 230 g/day in pregnancy, can have negative impacts on pregnancy maintenance, fetal weight, birth weight, colostrum yield and lamb survival. Caution must occur when trying to extrapolate these data to what might occur under pastoral grazing conditions. Indeed, Wallace et al. (2006a) stated that the data implied that it is the high-energy intakes are the primary cause of impaired placental development and adverse pregnancy outcomes in rapidly growing adolescents fed concentrate diets.

Under New Zealand's pastoral conditions, level of nutrition of the hogget during pregnancy has been shown to affect pregnancy loss rates, gestation length, lamb birth weight, ewe behaviour, lamb survival and live weight at weaning (Morris et al., 2005; Corner et al 2006a; Kenyon et al., 2008b; Mulvaney et al., 2008, 2010a, 2010b). Morris et al. (2005) reported live weight gains of 145 g/day and 210 g/day throughout pregnancy compared to 80 g/day resulted in higher lamb live weights to 100 days of age. Kenyon et al. (2008b) reported that live weight gains of 223 g/day vs. 134 g/day throughout pregnancy resulted in increased lamb and young dam live weights to 68 days after the mid-point of lambing. However, a group which gained 237 g/day from day 37 of pregnancy only, did not differ from those which gained at the high rate throughout pregnancy. The studies of Morris et al. (2005) and Kenyon et al. (2008b) reported no effect of live weight gain on pregnancy loss in mid – to late-pregnancy or lamb survival. However the study of Mulvaney et al. (2008) reported that hoggets that either maintained their live weight to day 87 of pregnancy followed by a gain of 190 g/day or gained 230 g/day throughout the entire pregnancy period were more likely to lose pregnancies between day 50 and term than those that gained at 130 g/day throughout pregnancy. They also reported that lambs born to hoggets that were fed to maintain live weight to day 87 of pregnancy followed by a gain of 190 g/day, had the lowest survival and weaning live

weight. It has been suggested that the pregnancy losses in the study of Mulvaney et al. (2008) were confounded by Neospora caninum (West et al., 2006; Howe et al., 2008) infection; therefore those results need to be interrupted with caution. Mulvaney et al. (2010b) reported that live weight gains of 151 to 158 g/day compared to 194 to 216 g/day throughout pregnancy did not affect pregnancy loss in mid – to late-pregnancy, lamb live weight or survival to the end of the study. Combined these studies indicate that live weight gains in the region of 150 – 200g/day throughout pregnancy are likely to maximise the outcome for the young dam and her offspring, although the benefit of live weight gains above 150 g/day may not be cost effective.

Schreurs et al. (2010a) modelled the effect of hogget live weight at breeding and at day 50 and 100 of pregnancy and at term on the performance of the hogget and her offspring to weaning. They reported that live weight at breeding had the biggest impact on lamb birth weight and weaning weight and weight of the dam at weaning. The impacts on lamb live weight and weight of the dam at weaning, per kg of hogget live weight in pregnancy, declined in the later stages of pregnancy. This indicates the importance of hogget breeding live weight.

A survey by Stevens (2001) showed that live weight gain (from breeding to 3-5 weeks pre-lambing) had a curvilinear relationship with lamb losses. Losses were reduced by approximately 3% per kg of hogget winter live weight gain over the range of 4 to 10 kg. The rate of lamb loss levelled off at live weight gains of 10-12 kg.

Abortive causes of pregnancy losses

Kenyon et al. (2004) reported that flocks vaccinated for toxoplasmosis and campylobacteriosis had higher lambing percentages. Although not reported in the literature, vaccination for salmonella could also reduce pregnancy losses on some farms. There has also been some evidence that *Neospora caninum* (West et al., 2006; Howe et al., 2008; Weston et al., 2009) causes reproductive loss in hoggets. However even when abortive tissue and the young dam have been examined for the known causes of abortion, a significant number of pregnancy losses go unexplained in ewe hoggets.

Shearing in mid pregnancy

Shearing mature ewes during pregnancy in New Zealand has been shown to enhance lamb live weight at birth and at weaning and lamb survival (Kenyon et al., 2003, 2006c; Corner et al., 2006b, 2007ab, 2010). The response to shearing appears to be most consistent when ewes are shorn in the mid-pregnancy period (Kenyon et al., 2003). To help ensure ewes are not adversely affected by cool conditions post shearing, they should be shorn with the cover (Dabiri et al., 1995) or snow comb. Only one study in New Zealand has examined the effect of shearing ewe hoggets in pregnancy (Kenyon et al., 2006d). Shearing was found to increase the birth weight of singleton lambs but not twins born to ewe hoggets. Mid-pregnancy shearing did not however influence lamb live weight at weaning or survival to weaning.

Hogget lamb mortality

Traditionally the mortality of lambs born to hoggets has been considered to be higher than those born to mature ewes. However, very few studies have actually compared this. Morris et al. (2000) and Annett and Carson (2006) examined survival of lambs born to first parity two-tooths and observed it to be lower than that of lambs born to multiparous mature ewes. In a comparison study, Mulvaney (2011) bred and lambed mature ewes and ewe hoggets in one group and found no difference in singleton lamb survival although they were lighter at birth and at weaning.

Across numerous studies mortality rates of lambs born to hoggets have been reported to be in the range of 12 to 60% (McCall & Hight 1981; McMillan 1983; McMillan & Kitney 1983; Stevens & McIntyre 1999; Stevens 2001; Morris et al., 2005; Kenyon et al., 2008b; Mulvaney et al., 2008; Mulvaney et al., 2010b; Schreurs et al., 2010) which tend to be greater than that reported for singletons and twin lambs born to mature ewes (Hight & Jury 1970; Dalton et al., 1980; Knight et al., 1988; Thompson et al., 2004; Everett-Hincks & Dodds 2008; Morel et al., 2009).

McMillan (1983) reported that dystocia was the single largest cause of death to day 3 of age in lambs born to hoggets, accounting for about 12 lambs per 100 lambs born while starvation/exposure caused almost 3 deaths per 100 lambs born. Young et al. (2010) also reported that dystocia was the major death risk for lambs born to hoggets although starvation/exposure was also a significant killer. Stevens (2001) reported farmer diagnoses of cause of death, and stated for singletons that 53% of deaths were due to dystocia and 10% due to starvation/exposure. In twins the numbers were 12% for dystocia and 41 % for starvation/exposure. Kenyon et al. (2004b) from a survey reported that farmer's indicated that 7% of their hoggets needed assistance during the lambing period and that 4% needed to be mothered up to their lambs.

In mature ewes the optimum birth weight range has been reported somewhere between 4.5 to 6.5 kg (Hight & Jury 1970; Dalton et al., 1980; Knight et al., 1988; Thompson et al., 2004; Everett-Hincks & Dodds 2008; Morel et al., 2009). McMillan (1983) reported that birth weight of lambs born to hoggets was an important factor in lamb deaths, with an optimum range of 3.3-4.1 kg. Birth weights of singleton lambs born to hoggets are known to be less than those born to mature ewes (Mulvaney 2011). Schreurs et al. (2010b) modelled the effect of

lamb birth weight on the survival of lambs born to hoggets and their results suggested birth weight has a positive relationship with survival until at least 5.0 kg.

Opinion is split on whether or not a high level of shepherding and lambing assistance is required with ewe hoggets. Based on survey results, Stevens (2001a, 2001b) recommended intensive shepherding. Kenyon et al. (2004b) from a survey reported no effect of frequency of supervision during lambing although, they did report separating singleton and twin bearing hoggets in lactation improved the lambing percentage.

Level of feeding in lactation

There has been a lack of research examining the effect of feeding level in lactation on the performance of the hogget and her offspring. Kenyon et al. (2004b) found, in a survey, that separating singleton – and twin-bearing hoggets in lactation improved the lambing percentage, which might suggest an advantage of improved nutrition for the twin bearing/lactating ewe hogget. However pasture mass and/or height at set stocking had no influence on lambing percentage. In mature ewes, it has been reported that ewe intake is not restricted when pasture covers/mass do not fall below 1000 – 1200 kg DM/ha and under these conditions lamb performance to weaning is not restricted (Morris et al., 1993, 1994; Morris and Kenyon 2004). Therefore it might be expected that the same pasture cover/mass minima be used for ewe hoggets.

Timing of weaning

Pregnancy and lactation can impact on the weight of the ewe hogget which can affect two-tooth live weight (Kenyon et al., 2008d). Negative effects of hogget breeding on two-tooth live weight and subsequent breeding performance are major concerns for farmers (Kenyon et al., 2004a). Weaning lambs born to hoggets relatively early allows more time for the hogget to gain live weight and potentially be heavier at two-tooth breeding. Weaning lambs born to mature ewes at 8 weeks of age, has been reported to have no detrimental effects on lamb growth rates (Rattray et al., 1976; Smeaton et al., 1979; Earl et al., 1990) while having positive effects on ewe live weight (Corbett & Furnival 1976; Smeaton et al., 1979). Mulvaney et al. (2009) reported that weaning at 10 weeks of age had no impact on lamb growth post weaning and had a small positive effect on live weight gain of the hogget. However, Mulvaney et al., (2011) reported weaning at either 9, 11 or 13 weeks had no impact on the weight of the hogget or her lambs.

Longer term impacts of hogget breeding

Effect of hogget lambing on subsequent production

An often stated concern of breeding ewe hoggets is that it will have negative effects on the young ewes' future live weight and reproductive performance. Studies have shown that breeding ewe hoggets can slightly reduce two-year-old (two-tooth) ewe breeding live weight (Keane 1974, Tyrrell 1976; Baker et al., 1981, McMillan & McDonald 1983; Kenyon et al. 2008d). However any effect on live weight has either had only a minor negative effect (Kenyon et al., 2008d), no effect (Suiter & Croker, 1970; Moore et al., 1983; Akcapinar et al., 2005) or even a positive effect (McCall & Hight 1981; Craig 1982; McMillan & McDonald 1983; Moore & Miller 1983) on two-year-old reproductive performance and the survival of their lambs. It is also important to note that any reduction in live weight as a two-year-old has been found to disappear by the weaning of their second set of lambs.

Hogget fleece weight can be reduced by hogget lambing although there is no flow on effect on the next year's production (Tyrrell 1976; Baker et al., 1981; McCall & Hight 1981).

Kenyon et al. (2011) reported there were no effects of ewe hogget breeding on breeding performance or number of fetuses per ewe presented for breeding in ewes aged 3 to 5 years of age. When the number of fetuses per ewe, for two-tooth breeding (Kenyon et al., 2008d) was combined with years 3 to 5, there was still no effect of hogget breeding on ewe reproductive performance post hogget breeding. This results complements previous work which showed that ewe pregnancy rates and number of lambs born per ewe as the ewe aged from two to six years of age did not differ (Cannon & Bath 1969; Baker et al., 1978; Ponzoni et al., 1979; Morel et al., 2010). However, when hogget performance was added to the lifetime data, then lifetime reproductive performance (from 8 months to five years) was increased (Kenyon et al., 2011) indicating that the relative success of hogget breeding on lifetime performance is very much dependant on the performance achieved as a hogget. Although no data were given in the survey of Stevens (2001), the author states lifetime performance was generally better in ewes that had been mated as hoggets, than in those that were not mated. Hogget breeding has been reported to have no effect on apparent ewe wastage (Ponzoni et al., 1979; Baker et al., 1981; Kenyon et al., 2011)

Can hogget breeding be used to accelerate genetic gain?

Hogget breeding and lambing offers an additional means of accelerating genetic gain. This can occur by reducing the generation interval (Schick, 2001). Further potential gains could be made by using a ram hogget with the ewe hoggets. Terrill (1982) calculated the increase in the reproductive rate of sheep averaged 0.5% per annum from 1940 to 1981. Terrill (1982) suggested progress of 2-5% per annum was possible by adopting a number of procedures, including mating of ewe hoggets. Although farmers acknowledge hogget breeding can increase genetic gain very few actually keep replacements born to ewe hoggets (Kenyon et al., 2004b).

How does achieving puberty as a hogget affect potential future performance?

A number of studies have shown a positive relationship between the achieving puberty or the incidence of oestrus (heat) as a hogget and future reproductive performance and lamb production, irrespective of whether ewes were bred as a hoggets or not. Romney ewe two-year old fertility is known to be genetically correlated with hogget oestrus (Chang & Rae 1972) which itself is under genetic control (Chang & Rae 1970). In their review, McMillan & Moore (1983), distinguish between "passively" and "actively" capitalising on hogget oestrus (heat) activity. They suggested farmers can capitalise on hogget oestrous activity "passively" – by using hogget oestrus (heat) as an early index of subsequent lamb production or "actively" – by breeding hoggets at 8 – 9 months of age. It has been found that there are effects of hogget oestrus on two-tooth reproduction over and above any live weight effect although the effect tends to diminished as the ewe gets older (Hulet et al., 1969; Hight & Jury 1976; Moore et al., 1978; Moore & Hockey, 1982; Moore & Smeaton 1980). Thus, those hoggets which display hogget oestrus (heat) produce more lambs as adult ewes (i) because they are heavier, and (ii) because they have more lambs at a given live weight. In addition, the daughters of these ewes which display oestrus as a hogget may have a higher genetic potential for lamb production. Hogget oestrus also appears to influence subsequent two-tooth milk production, but this is likely a reflection of the hogget live weight advantage (Knight et al., 1995).

Should hoggets that fail to breed be culled?

Baker et al. (1981) found that ewes that did not lamb as a hogget tended to wean fewer lambs as a two-tooth. Similarly, Moore et al. (1983) reported that ewes that did not become pregnant as a hogget were less likely to get pregnant and wean a lamb as a two-tooth.

Kenyon et al. (2011) reported that the lifetime performance of ewes which failed to breed as a hogget did not differ from those which were not presented for breeding as a hogget. Baker et al. (1978) reported no difference in reproductive performance between ewes that did not lamb as a hogget and those that successfully lambed. Kenyon et al. (2011) however, reported that those that did lamb as a hogget had greater lifetime (8 months to 5 years) performance than those which failed to breed as a hogget. In support of this, Fogarty et al. (2007) reported that ewes which successfully reared a lamb as a hogget subsequently reared more lambs to weaning in their second and third lambings than those that did not and Baker et al. (1981) reported that ewes that did not lamb as a hogget weaned fewer lambs during their next three years than those that did lamb as a hogget. Combined these studies indicate that another potential advantage of hogget breeding is that those that fail to breed at 8-9 months, but are of suitable live weight, are likely to be less productive in future years (Kenyon et al. 2008d) and may not be suitable replacements.

Potential intergenerational effects of hogget breeding

Craig (1982) examined the records of 27,181 ewe hoggets that were mated over 1973 – 1980 in the Waihora Group Breeding Scheme and concluded that progeny of hoggets were severely handicapped and suggested they were less suitable to be retained in the breeding flock. Loureiro et al. (2010) reported fetuses from ewe hoggets tended to be lighter than those from mature ewes. In support of this Mulvaney (2011) reported offspring born to ewe hoggets were lighter at birth and to weaning than those born to mature ewes. Further Loureiro et al. (2011) reported that offspring born to ewe hoggets were lighter to at least one year of age. This might suggest their two-tooth performance could be impaired. There are sparse New Zealand data on lifetime effects of being born to a hogget compared to a mature ewe, when both classes of ewe have been bred together with the same rams.

Kenyon et al. (2008e) examined the performance of offspring born to traditional first lambing two-tooths or second lambing two-tooths (i.e. those that had been bred successfully as a hogget). They reported no difference in live weight or reproductive performance of the progeny to two-years of age.

REFERENCES

Akcapinar H, Unal N, Atasoy F. (2005). The effects of early age mating on some production traits of Bafra (Chios x Karayaka) sheep. *Turkish Journal of Veterinary and Animal Science* 29, 531-536

Allison AJ, Kelly RW, Lewis J S, Binnie DB. (1975). Preliminary studies on the efficiency of mating of ewe hoggets. *Proceedings of the NZ Society of Animal Production* 35: 83-90.

Annett RW, Carson AF. (2006). Effect of plane of nutrition during the first month of pregnancy on conception rate, foetal development and lamb output of mature and adolescent ewes. *Animal Science* 82; 947-954.

Baker RL, Clark JN, Carter AH, Diprose GD. (1979). Genetic and phenotypic parameters in NZ Romney Sheep. I. Body weights, fleece weight and oestrous activity. *NZ Journal of Agricultural Research* 22: 9-21.

Baker RL, Steine FA, Vabenoe AW, Bekken A, Gjedrem T (1978). Effect of mating ewe lambs on lifetime performance. *Acta Agriculturae Scandinavica* 28: 203-217.

Baker RL, Clark RN, Diprose GD. (1981). Effect of mating Romney ewe hoggets on lifetime production – preliminary results. *Proceedings of the NZ Society of Animal Production* 41: 198-203.

Baker RL, Clark JN, Harvey G. (1985). Crossbred performance of Border Leicesters and Coopworths and six strains of Romneys. *NZ Ministry of Agriculture & Fisheries, Agricultural Research Division Annual Report* 1984 185: 38-39.

Beck NFG, Davies MCG. (1994). The effect of stage of breeding season or pre-mating oestrogen and progesterone therapy on fertility in ewe lambs. *Animal production* 59; 429-434.

Beck NFG, Daveis MCG, Davies B. (1996). A comparison of ovulation rate and late embryonic mortality in ewe lambs and ewes and the role of late embryo loss in ewe lamb subfertility. *Animal Science* 62; 79-83.

Bister JL, Dercyke G, Noel B, Paquay R. (1991). Production and economic consequences of using yearling lambs for breeding. 2. Effect on subsequent performance and economic consequences. *Revue de'l Agriculture* 44: 1213-1222.

Cannon DJ, Bath JG. (1969). Effect of age at first joining on lifetime production by Border Leicester x Merino ewes. *Australian Journal of Experimental Agriculture and Animal Husbandry* 9: 477-491.

Cave LM, Kenyon PR, Morris ST. (2012). Effect of timing of exposure to vasectomised rams and body condition score on the breeding performance of ewe hoggets. *Animal production Science* (in press)

Chang TS, Rae AL. (1970). The genetic basis of growth, reproduction, and maternal environment in Romney ewes. I. Genetic variation hogget characters and fertility of the ewe. *Australian Journal of Agricultural Research* 21; 115–129.

Chang TS, Rae AL .(1972). The genetic basis of growth, reproduction, and maternal environment in Romney ewes. II. Genetic covariation between hogget characters, fertility, and maternal environment of the ewe. *Australian Journal of Agricultural Research* 23; 149–165.

Corbett JL, Furnival EP. (1976). Early weaning of grazing sheep: 2. Performance of ewes. *Australian Journal of Experimental Agriculture and Animal Husbandry* 16; 156-166.

Corner R.A., Kenyon PR, Stafford KJ, West DM, Morris ST. (2006a). The effect of nutrition during pregnancy on the behaviour of adolescent ewes and their lambs(s) within 12 hours of birth. *Proceedings of the New Zealand Society of Animal Production* 66; 439 – 443.

Corner RA, Kenyon PR, Stafford KJ, West DM, Oliver MH. (2006b). The effect of mid-pregnancy shearing or yarding stress on ewe post-natal behaviour and the birth weight and post-natal behaviour of their lambs. *Livestock Science* 102; 121–129.

Corner RA, Kenyon PR, Stafford KJ, West DM, Oliver MH. (2007a) The effect of mid-pregnancy stressors on twin-lamb live weight and body dimensions at birth. *Livestock Science* 107; 126–131.

Corner RA, Kenyon PR, Stafford KJ, West DM,Oliver MH. (2007b). The effect of mid-pregnancy shearing and litter size on lamb birth weight and post-natal plasma cortisol response. *Small Ruminant Research* 73; 115–121

Corner RA, Kenyon PR, Stafford KJ, West DM, Oliver MH. (2010). The effect of different types of stressors during mid – and late – pregnancy on lamb weight and body size at birth. *Animal* 4; 2065–2070.

Craig RL. (1982). Breeding from Romney ewe hoggets in the Waihora Group Breeding Scheme. *NZ Agricultural Science* 16: 101-104.

Da Silva P, Aitken RP, Rhind SM, Racey PA, Wallace JM. (2003). Effect of maternal overnutrition during pregnancy on pituitary gonadotrophin gene expression and gonadal morphology in female and male foetal sheep at day 103 of gestation. *Placenta* 24; 248-257.

Dabiri, N.; Holmes CW, McCutcheon, S.N.; Parker, W.J.; Morris, S.T. (1995). Resistance to cold stress in sheep shorn by cover comb or standard comb. *Animal Science* 60; 451-456.

Dalton DC, Knight TW, Johnson DL. (1980). Lamb survival in sheep breeds on NZ hill country. *NZ Journal of Agricultural Research* 23: 167-173.

During CP, Dyson CB, Webby RW. (1980). Relationship of pasture parameters to live weight gain of hoggets on North Island hill country. *Proceedings of the New Zealand Society of Animal Production* 40: 90-105.

Dyrmundsson OR. (1973). Puberty and early reproduction performance in sheep. I. Ewe lambs. *Animal Breeding Abstracts* 41: 273-289.

Dyrmundsson OR. (1981). Natural factors affecting puberty and reproductive performance in ewe lambs: A review. *Livestock Production Science* 8; 55-65.

Earl CR, Dunstan EA, Stafford JP, Male RH, Rowe JP. (1990.) Early weaning of crossbred lambs. *Proceedings of the Australian Society of Animal Production* 18; 192-195.

Edey TN,Chu TT, Kilgour R, Smith JF, Tervitt HR. (1977). Estrus without ovulation in puberal ewes. *Theriogenology* 7; 11-15.

Edey TN, Kilgour R, Bremner K. (1978). Sexual behaviour and reproductive performance of ewe lambs at and after puberty. *Journal of Agricultural Science* (Cambridge) 90; 83-91.

Elvidge DG, Coop IE. (1974). Effect of shearing on feed requirements of sheep. *New Zealand Journal of Experimental Agriculture* 2, 397–402

Everett-Hincks JM, Dodds KG. (2008). Management of maternal-behaviour to improve lamb survival in easy care sheep systems. *Journal of Animal Science* 86(ESuppl.), E259–E270.

Forgarty NM, Ingham VM, Gilmour AR, Afolayan RA, Cummins LJ, Hocking Edwrds JE, Gaunt GM. (2007). Genetic evaluation of crossbred lamb production. 5. Age of puberty and lambing performance of yearling crossbred ewes. *Australian Journal of Agricultural Science* 58: 928–934.

Gaskin CT, Snowder GD, Westman MK, Evans M. (2005). Influence of body weight, age and weight gain on fertility and prolificacy in four breeds of ewe lambs. *Journal of Animal Science* 83; 1680-1689.

Gordon I. (1999). Breeding sheep at younger ages. In: Controlled reproduction in sheep and goats volume 2. CABI Publishing, New York, USA. 341-344.

Hare L, Bryant MJ. (1985). Ovulation rate and embryo survival in young ewes mated either at puberty or at the second or third oestrus. *Animal Reproduction Science* 8: 41-52.

Hight CK, Jury KE. (1970). Hill country sheep production. II. Lamb mortality and birth weights in Romney and Border Leicester x Romney flocks. *NZ Journal of Agricultural Research* 13: 735-752.

Hight GK, Jury KE. (1976). Hill country sheep production. VIII. Relationship of hogget and two-year old oestrus and ovulation rate to subsequent fertility in Romeny and Border Leicester x Romney ewes. *NZ Journal of Agricultural Research* 19: 281-288.

Howe L, West DM, Collet MG, Tattersfield G, Pattison RS, Pomroy WE, Kenyon PR, Morris ST, Williamson NB. (2008). The role of Neospora caninum in three cases of unexplained ewe abortions in the southern North Island of New Zealand. *Small Ruminant Research* 75; 115-122.

Hulet CV, Wiggins EL, Ercanbrack SK. (1969). Estrus in range lambs and its relationship to lifetime reproductive performance. *Journal of Animal Science* 28; 246-252.

Jagusch KT, Rattray PV, Winn GW, Scott ME. (1979). Crops, legumes, and pasture for finishing lambs. *Proceedings of the Ruakura Farmers Conference* 42: 47-52.

Keane MG. (1974). Effect of previous lambing on body weight and reproductive performance of hoggets. *Irish Journal of Agricultural Research* 13: 191-196.

Keane MG. (1976). Breeding from ewe lambs. *Farm and Food Research* 7: 10-12.

Kenyon PR, Morris ST, Revell DK, McCutcheon SN. (2003). Shearing during pregnancy – review of a policy to increase birthweight and survival of lambs in New Zealand pastoral farming systems. *New Zealand Veterinary Journal* 51; 200–207.

Kenyon PR, Morris ST, Perkins NR, West DM. (2004a). Hogget mating in New Zealand – a survey. *Proceedings of the New Zealand Society of Animal Production* 64; 217-222.

Kenyon PR, Pinchcheck GL, Perkins NR, Morris ST, West DM. (2004b). Identifying factors which maximise the lambing performance of hoggets: a cross-sectional experiment. *New Zealand Veterinary Journal* 52; 371-377.

Kenyon PR, Morel PCH, Morris ST, West DM. (2005). The effect of individual liveweight and use of teaser rams prior to mating on the reproductive performance of ewe hoggets. *New Zealand Veterinary Journal* 53; 340-343.

Kenyon PR, Morel PCH, West DM, Morris ST. (2006a). Effect of liveweight and teasing of ewe hoggets prior to breeding on lambing pattern and weight of singleton lambs. *New Zealand Journal of Agricultural Research* 49; 341-347.

Kenyon PR, Morel PCH, Morris ST, Burnham DL, West DM. (2006b). The effect of length of use of teaser rams prior to mating and individual liveweight on the reproductive performance of ewe hoggets. *New Zealand Veterinary Journal* 54; 91-95.

Kenyon PR, Revell DK and Morris ST. (2006c). Mid-pregnancy shearing can increase birth weight and survival to weaning of multiple-born lambs under commercial conditions. *Australian Journal of Experimental Agriculture* 46; 821–825.

Kenyon, P.R., Sherlock, R.G., Morris, S.T., Moral, P.C.H. (2006d). The effect on mid – and late-pregnancy shearing of hoggets on lamb birth weight, weaning weight, survival rate, and wool follicle and fibre characteristics. *Australian Journal of Agricultural Research* 57; 877 – 882.

Kenyon, PR, Morel PCH, Morris ST, Burnham DL, West DM. (2007a). The effect of teaser ratio prior to breeding on the reproductive performance of ewe hoggets. *New Zealand Veterinary Journal* 55; 342-345.

Kenyon PR, Morel PCH, West DM, Morris ST. (2007b). Effect of age of ram on the reproductive performance of ewe hoggets. *New Zealand Veterinary Journal* 55; 184-187.

Kenyon PR, Morel PCH, West DM, Morris ST. (2008a). A note on the effect of vasectomised rams and short – term exposure to entire rams prior to the breeding period on the reproductive performance of ewe lambs. *Applied Animal Behavior Science* 110; 397-403.

Kenyon PR, Morris ST, West DM. (2008b). Effects of nutrition during pregnancy on hogget pregnancy outcome and birthweight and liveweights of lambs. *New Zealand Journal of Agricultural Research* 51; 77-83.

Kenyon PR, Morris ST, West DM. (2008c). Can ram lambs whose scrotum had been shortened by the use of a rubber ring be used as an alternative to vasectomised Perendale rams for inducing early breeding activity in Romney ewe lambs? *New Zealand Veterinary Journal* 56; 326-329.

Kenyon PR, Proctor L, Morel PCH, Morris ST, West DM. (2008d). The effect of breeding ewe lambs on subsequent two-year-old ewe performance. *Livestock Science* 115; 206-210.

Kenyon, P.R.; Morris, S.T.; Blair, H.T.; Stafford, K.J. (2008e). Does dam parity affect the performance of ewe progeny born to 2-year-old ewes? *Australian journal of experimental agriculture* 48: 1019-1023.

Kenyon PR, Smith SL, Morel PCH, Morris ST, West DM. (2009). The effect of the maturity and prior breeding activity of rams and body condition score of ewe hoggets on the reproductive performance of ewe hoggets. *New Zealand Veterinary Journal* 57; 290-294.

Kenyon PR, Morris ST, West DM. (2010). The proportion of rams and the condition of ewe lambs at joining influences their breeding performance. *Animal Production Science* 50; 454-459.

Kenyon, P.R., van der Linden, D.S., West, D.M., Morris, S.T. (2011). The effect of breeding hoggets on lifetime performance. *New Zealand Journal of Agricultural Research* 54; 321-330.

Knight TW, Hall DRH, Wilson LD. (1982). Effect of pre-joining shearing and stress on ovulation rate. *NZ Ministry of Agriculture & Fisheries Agricultural Research Division Annual Report* 1981 182: 114.

Knight TW, Lynch PR, Hall DRH, Hockey H-UP. (1988). Identification of factors contributing to increased lamb survival in Marshall Romney sheep. *NZ Journal of Agricultural Research* 31:259-271.

Knight TW, Gosling LS, Dick HA. (1995). Effects of hogget oestrus and the lambing and milking of hoggets on the subsequent milk composition and yields of two-year old Dorset ewes. *NZ Journal of Agricultural Research* 38: 197-204.

Lewis KHC. (1959). Mating of hoggets. *Proceedings of the New Zealand Society of Animal Production* 19; 111-119.

Loureiro, MFP, Pain, SJ, Kenyon PR, Blair HT. (2010). Do fetuses from primiparous one-year-old ewes differ from those of multiparous mature ewes? *Proceedings of the New Zealand Society of Animal Production* 2010. Vol 70: 118-120.

Loureiro, M.F.P., Paten, A.M., Asmad, K., Pain, S.J., Kenyon, P.R., Pomroy, W.E., Scott, I., Blair, H.T. (2011). The effect of dam age and lamb birth rank on the growth rate, faecal egg count and onset of puberty of single and twin female offspring to 12 month of age. *Proceedings of the New Zealand Society of Animal Production* 71: 83-85

McCall DG. (1978). Factors affecting hogget lambing performance. *Whatawhata Hill Country Research Station, Annual Report* 1977 178: 3-4.

McCall DG, Hight CK. (1981). Environmental influences on hogget lambing performance and the relationship between hogget and two-tooth lambing performance. *NZ Journal of Agriculture Research* 24: 145-152.

McMillan WH, Parker WJ. (1981). Mating of ewe hoggets – An appraisal for a Wairarapa farm. *Massey University Riverside Farm Publication* No. 5: 35-45.

McMillan WH, Knight TW. (1982). Shearing and time of joining effects on reproduction in two-tooth ewes. *Proceedings of the NZ Society of Animal Production* 42: 45-46.

McMillan WH, Wilson LD (1982) Autumn shearing and level of rearing effects on hogget reproduction. *Ministry of Agriculture & Fisheries Agricultural Research Division Annual Report* 1981 182: 114.

McMillan WH. (1983). Hogget lamb mortality. *Proceedings of the NZ Society of Animal Production* 43: 33-36.

McMillan WH, Kitney IW. (1983). Hogget reproductive performance studies in commercial flocks. *NZ Ministry of Agriculture & Fisheries, Agricultural Research Division Annual Report* 1982 183: 141-142.

McMillan WH, McDonald MF. (1983). Reproduction in ewe lambs and its effects on two-year old performance. *NZ Journal of Agricultural Research* 26: 437-442.

McMillan WH, Moore RW. (1983). Capitalising on hogget oestrus. *Proceedings of Sheep & Beef cattle Society of the NZ Veterinary Association* 13: 47-52.

McMillan WH, Wilson LD. (1983). Hogget reproduction responses to shearing and rearing level. *Ministry of Agriculture & Fisheries Agricultural Research Division Annual Report* 1982 183: 142.

McMillan WH, McDonald MF. (1985). Survival of fertilised ova from ewe lambs and adult ewes in the uteri of ewe lambs. *Animal Reproduction Science* 8: 235-240.

McMillan WH, Malthus IC, Clarke JN, Aymes NC. (1988). Early growth and reproduction of exotic sheep breeds. *Proceedings of the NZ Society of Animal Production* 48: 49-51.

Meyer HH, French RL. (1979). Hogget liveweight – oestrus relationship among sheep breeds. *Proceedings of the NZ Society of Animal Production* 39: 56-62.

Meyer HH. (1981). Early predictors of ewe fertility. *Proceedings of the NZ Society of Animal Production* 41: 204-208.

Moore RW, Knight TW, Whyman D (1978) Influence of hogget oestrus on subsequent ewe fertility. *Proceedings of the New Zealand Society of Animal Production* 38; 90-96.

Moore RW, Smeaton DC. (1980). Effects of different growth paths from 4 to 1 months of age on Romney hogget oestrus and subsequent reproduction. *Proceedings of the NZ Society of Animal Production* 40: 27-33.

Moore RW, Smeaton DC. (1980). Effects of different growth paths from 4 to 11 months of age on Romney hogget oestrus and subsequent reproduction. *Proceedings of the New Zealand Society of Animal Production* 40; 27-33.

Moore RW, Hockey H-UP. (1982). The effect of early nutrition and hogget oestrus on subsequent reproduction. *Proceedings of the NZ Society of Animal Production* 42: 41-43.

Moore RW, Miller CM. (1982). The effect of early rearing on the growth and subsequent reproduction of Romney ewes. *NZ Ministry of Agriculture & Fisheries, Agricultural Research Division Annual Report* 1981 182: 113.

Moore RW, Sumner RMW, Bass JJ, Hockey H-UP. (1983). Hogget lambing and its effect on the subsequent two-tooth performance of three breeds. *Proceedings of the NZ Society of Animal Production* 43: 21-24.

Moore RW, Sumner RMW, Miller CM. (1984). The effect of hogget lambing on subsequent performance of three breeds. *NZ Ministry of Agriculture & Fisheries, Agricultural Research Division Annual Report* 1983 184: 137.

Moore RW, McMillan WH, Dockrill G, Dow BW. (1989). Lambing of Romney and Booroola cross hoggets with and without the F gene under different pasture allowances. *Proceedings of the NZ Society of Animal Production* 49: 281-283.

Morel PCH, Morris ST, Kenyon PR. (2009). Effects of birth weight on survival in twin born lambs. *Proceedings of the New Zealand Society of Animal Production* 69, 75–79.

Morel PCH, Wickham JL, Morel JP, Wickham GA. (2010). Effect of birth rank and yearling lambing on long-term ewe reproductive performance. *Proceedings of the New Zealand Society of Animal Production* 70: 88-90.

Morris, S. T.; Parker, W. J.; Burnham, D. L.; Jenkinson, C. M. C.; McCutcheon, S. N. (1993). Herbage allowance-intake production relationships in continuously stocked winter – and spring-lambing ewes. *Proceedings of the New Zealand Society of Animal Production* 53: 11–14.

Morris, S. T.; McCutcheon, S. N.; Parker, W. J.; Blair, H. T. (1994). Effects of sward height on herbage intake and performance of lactating ewes lambed in winter and continuously stocked on pasture. *Journal of Agricultural Science, Cambridge* 122:471–482.

Morris CA, Hickey SM, Clarke JN. (2000). Genetic and environmental factors affecting lamb survival at birth and through to weaning. *New Zealand Journal of Agricultural Research* 43; 515-524.

Morris ST, Kenyon PR. (2004). The effect of litter size and sward height on ewe and lamb performance. *New Zealand Journal of Agricultural Research* 47, 275–286.

Morris ST, Kenyon PR, West DM. (2005). Effect of hogget nutrition in pregnancy on lamb birth weight and survival to weaning. *New Zealand Journal of Agricultural Research* 48; 165-175.

Muir P. (2001). finding out more about hogget oestrus. *Meat NZ R & D Brief* 92 (March 2001): 2 pp.

Mulvaney FJ, Kenyon PR, Morris ST, West DM. (2008). Ewe lamb nutrition during pregnancy affects pregnancy outcome. *Australian Journal of Experimental Agriculture* 48; 1085-1089.

Mulvaney, F.J., Morris, S.T., Kenyon, P.R., West, D.M., Morel, P.C.H. (2009). The effect of weaning at 10 or 14 weeks of age on liveweight changes in the hogget and her lambs. *Proceedings of the New Zealand Society of Animal Production* 69: 68 – 70.

Mulvaney FJ, Morris ST, Kenyon PR, Morel PCH, West DM. (2010a). Effect of nutrition pre-breeding and during pregnancy on breeding performance of ewe lambs. *Animal Production Science* 50, 953-960.

Mulvaney FJ, Morris ST, Kenyon PR, West DM, Morel PCH. (2010b). Effect of live weight at the start of the breeding period and live weight gain during the breeding period and pregnancy on reproductive performance of hoggets and the live weight of their lambs. *New Zealand Journal of Agricultural Research* 53; 355-364.

Mulvaney FJ. (2011). Investigating methods to improve the reproductive performance of hoggets. *PhD Thesis, Massey University, New Zealand*.

Mulvaney, F.A., Morris, S.T., Kenyon, P.R., Morel, P.C.H., West D.M. (2011). Is there any advantage of early weaning of twin lambs born to hoggets? *Proceedings of the New Zealand Society of Animal Production*, 71: 79 – 82.

Parr RA, Davis IF, Fairclough RJ, Miles MA (1987). Overfeeding during early-pregnancy reduces peripheral progesterone concentration and pregnancy rate in sheep. *Journal of Reproduction and Fertility*, 80; 317-320.

Ponzoni RW, Azzarini M, Walker SK. (1979). Production in mature corriedale ewes first mated at 7 to 11 or 18 months of age. *Animal Production* 29: 385-391.

Quirke JF. (1981). Regulation of puberty and reproduction in female lambs: a review. *Livestock Production Science* 8; 37-53.

Quirke JF, Hanrahan JP. (1977). Comparison of the survival in the uteri of adult ewes of cleaved ova from adult ewes and ewe lambs. *Journal of Reproduction and Fertility.* 51; 487-489.

Rattray PV, Morrison MCL, Farquhar PA. (1976). Performance of early-weaned lambs on lucerne and pasture. *Proceedings of the New Zealand Society of Animal Production* 36; 179-183.

Schick G. (2001). Hogget mating – Will you follow the trend? *Wool Grower* Summer 2001: 25-26.

Schreurs NM, Kenyon PR, Mulvaney FJ, Morel PCH, West Dm, Morris ST. (2010a). Response of additional ewe lamb liveweight during gestation on birth and weaning weight of offspring and liveweight of the ewe lamb at weaning. *Animal Production Science* 50; 528-532.

Schreurs NM, Kenyon PR, Mulvaney FJ, Morel PCH, West Dm, Morris ST. (2010b). Effect of birth weight and birth rank on the survival of single and twin lambs born to ewe lambs. *Animal Production Science* 50; 460-464.

Smeaton DC, Knight TW, Sumner RMW. (1979). 'Effect of early weaning on ewe liveweight and ovulation rate at mating'. *(Agricultural Research Division Annual report 1979/1980, Ministry of Agriculture and Fisheries, Wellington, New Zealand)*.

Smith JF, Parr J, Murray G, Harris C, Duganzich DM. (1995). Effect of selection for early lambing on the expression of hogget oestrus activity. *Proceedings of the NZ Society of Animal Production* 55: 154-156.

Smith JF, Knight TW. (1998). Reproductive management of sheep. Reproductive Management of Grazing Ruminants in NZ. *NZ Society of Animal Production Occasional Publication* No 12: 113-143.

Stephenson SK, Dalton DC, Kirton AH. (1980). The relationships between growth, body shape and body composition to the initiation of oestrus activity in different sheep breeds. *Proceedings of the NZ Society of Animal Production* 40: 258-267.

Stevens D, McIntyre S. (1999). Hogget mating survey. *AgResearch Wool Pro Internal Report*. 24 pp.

Stevens DR. (2001a). Best management practices for hogget lambing. Otago Southland Hogget Survey Group. *Final Report Autumn* 2001. 12pp plus appendix.

Stevens DR .(2001b). Best management practices for hogget mating. *Report of premating feeding Autumn 2000. OtagolSouthiand Hogget Survey Group. A FITT Funded Meat NZ and Wool Pro Project:* 6 pp.

Suiter RJ, Croker KP. (1970). Mating weaners does not affect future ewe performance. *Journal of Agriculture: Western Australia* 11, 92,

Sumner RMW, Bigham ML, Knight TW, McMillan WH, Wiggins LK. (1982). Shearing – its effects on production. *Proceedings of the Ruakura Farmers Conference*. 31–34.

Terrill CF. (1982). Combining of genetic and reproductive techniques to increase efficiency of commercial meat production. *Proceedings of the 2nd World Congress on Genetics applied to Livestock Production Symposia:* 489-492.

Thompson BC, Muir PD, Smith NB. (2004). Litter size, lamb survival, birthand twelve week weight in lambs born to cross-bred ewes. *Proceedings of the New Zealand Grassland Association* 66, 233–237.

Tyrell RN. (1976). Some effects of pregnancy in eight-month old Merino ewes. *Australian Journal of Experimental Agriculture & Animal Husbandry* 16: 458-461.

Wallace JM, Aitken RP, Cheyne MA. (1996). Nutrient partitioning and fetal growth in rapidly growing adolescent ewes. *Journal of Reproduction & Fertility* 107: 183-190.

Wallace JM, Aitken RP, Cheyne MA, Humblot P. (1997a). Pregnancy-specific protein B and progesterone concentrations in relation to nutritional regimen, placental mass and pregnancy outcome in growing adolescent ewes carrying singleton fetuses. *Journal of Reproduction & Fertility* 109: 53-58.

Wallace JM, Da Silva P, Aitken RP, Cruickshank MA. (1997b). Maternal endocrine status in relation to pregnancy outcome in rapidly growing adolescent sheep. *Journal of Endrocrinology* 155: 359-368.

Wallace JM, Bourke DA, Aitken RP, Palmer RM, Da Silva P, Cruickshank MA. (2000). Relationship between nutritionally-mediated placental growth restriction and fetal growth, body composition and endocrine status during late gestation in adolescent sheep. *Placenta* 21; 100-108.

Wallace JM, Bourke DA, Aitken RP, Milne JS, Hay Jr WW. (2002a). Placental glucose transport in growth-restricted pregnancies induced by overnourishing adolescent sheep. *Journal of Physiology* 547; 85-94.

Wallace JM, Bourke DA, Aitken RP, Leitch N, Hay Jr WW. (2002b). Blood flows and nutrient uptakes in growth-restricted pregnancies induced by overnourishing adolescent sheep. *American Journal of Physiology – Regulatory, Integrative and Comparative Physiology* 282; R1027-R1036.

Wallace JM, Bourke DA, Da Silva P, Aitken RP. (2003). Influence of progesterone supplementation during the first third of pregnancy on fetal and placental growth in overnourished adolescent ewes. *Reproduction* 126; 481-487.

Wallace JM, Matsuzaki M, Milne J, Aitken R. (2006a). Late but not early gestational maternal growth hormone treatment increases fetal adiposity in overnourished adolescent sheep. *Biology of Reproduction* 75; 231-239.

Wallace JM, Milne JS, Redmer DA, Aitken RP. (2006b). Effect of diet composition on pregnancy outcome in over nourished rapidly growing adolescent sheep. *British Journal of Nutrition* 96; 1060-1068.

West DM, Pomroy WE, Collet MG, Hill FI, Ridler A, Kenyon PR, Morris ST, Pattision RS. (2006). A possible role for Neospora caninum in ovine abortion in New Zealand. *Small Ruminant Research* 62; 135-138.

Weston, J.F., Howe, L., Collett, M.G., Pattison, R.S., Williamson, N.B., West, D.M., Pomroy, W.E., Syed-Hussain, S.S., Morris, S.T., Kenyon, P.R. (2009). Dose-titration challenge of young pregnant sheep with Neospora caninum tachyzoites. *Veterinary Parasitology* 164: 183 – 191

Winn CW, Cumberland GLP. (1974). Relationships of various parameters with lambing performance of hoggets. *Proceedings of the NZ Society of Animal Production* 35: 100-101.

Young EA, Yuan JV, Everett-Hincks J. (2010). Yearling lambing performance and primary cause of lamb death. *Proceedings of the New Zealand Society of Animal Production* 70; 96-100

Zain AED, Mousa M. (1999). The effect of stage of breeding season and administration of fertirelin acetate (GnRH analogue) post-mating on ovarian activity and fertility in ewe lambs. *Assieut Veterinary Medical Journal* 42: 353-370.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