Chapter 3
MATING & EARLY PREGNANCY

Recommendations

- *Continued high ewe live weight and condition score during mating mean good ovulation rate and potential lamb drop.*
- *It is important that ewes not only reach good weight at mating but that they are increasing in live weight during the early mating period.*
- *Minimise stress (e.g., yarding, shearing, sudden feed changes) during mating- early pregnancy to avoid upsetting oestrus and to maximise embryo survival.*
- *Avoid shearing from two weeks before until two weeks after mating.*
- *Good feeding in early pregnancy is important for early placental development, which in turn boosts lamb birth weight and survival (especially of multiples).*
- *Ewes need 1.0 to 1.3 kg of dry matter per day (average to good quality) to hold body condition score during mating and early pregnancy.*
- *Hoggets to be mated must be well grown and close to 40 kg live weight at mating which should be one cycle later than for the ewe flock.*
- *Ewes must be removed from pastures containing zearalenone well before mating, particularly if levels from urine tests have been high.*
- *Ewe:ram ratios can be 150+:1 for well prepared ewes and rams but the ratio should be less than 100:1 for ewe and/or ram hoggets.*

This chapter covers mating and early pregnancy to the end of the first third (day 50) of pregnancy. This will include the 35-42 days the rams are with the ewes plus a week or two following mating. Priorities include maximising the number of lambs conceived, embryo implantation and survival and early development of the placenta for good lamb birth weight and survival.

Potential lambing percentage is determined during the mating-early pregnancy period by:

- ewe and ram fertility
- ewe ovulation rates
- conception rates
- successful establishment of the embryo

If potential is low (e.g. due to poor ovulation rate) then good management from mating to tailing cannot remedy the situation but it will help lamb survival. If the potential is high, management to maximise lamb survival becomes critical. The implantation period (12-14 days after fertilisation), when the embryo becomes established in the uterus, is also critical.

The ewe

Good ewe health and body condition (CS3 or greater) at mating is critical in achieving a high pregnancy rate and establishing a pregnancy that is likely to result in healthy lambs at docking.

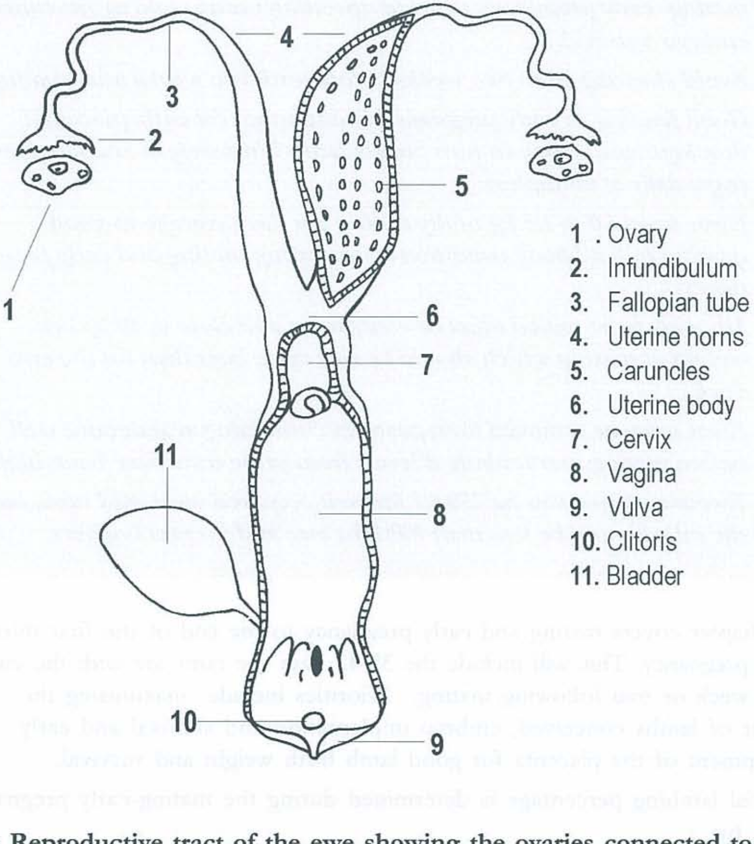

Fig. 3: Reproductive tract of the ewe showing the ovaries connected to the two uterine horns by the fallopian tubes or oviducts. Eggs from the ovaries are fertilised by ram sperm in the fallopian tube and 12-14 days later implant into the wall of the uterus where as embryos they connect via the placenta to caruncles for transfer of nutrients from the ewe.

Physiological Changes of Reproduction in the Ewe

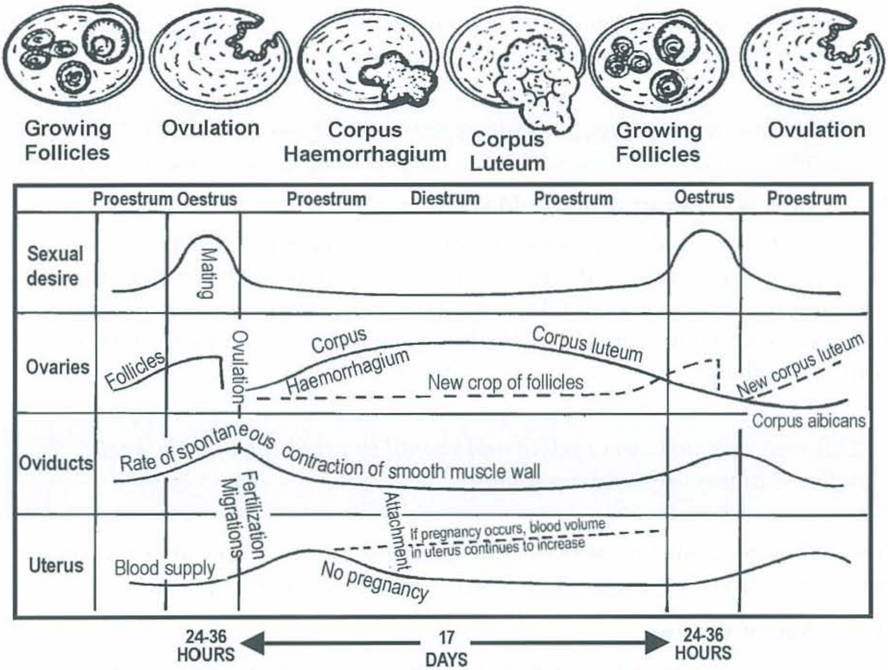

Fig.4: Physiological and hormonal changes during the oestrus cycle in ewes. Oestrus is brought about by oestrogen from developing follicles on the ovary and progesterone from the corpus luteum. Progesterone priming is essential and the reason for a silent heat at first oestrus is because there is no corpus luteum to produce progesterone. Eggs are released into the funnel of the fallopian tube infundibulum near the end of the oestrus period where they are fertilised and progesterone from the corpus luteum prepares the uterus for implantation. Then oestrus cycling ends and gestation begins.

Oestrus

Oestrus is the period, averaging 30 hours, when ewes will accept ram service.

Oestrus is the period when the ewe will accept service by the ram. Oestrus usually lasts about 24 hours but varies from 4–72 hours depending on ewe age, breed and degree of contact with the ram. The oestrus interval averages 17 days (range 15–18 days). There are no obvious behaviour changes (such as those shown by cattle) and rams detect ewes in oestrus mainly by odour from pheromones (external hormones). Ewes in oestrus, especially experienced breeders, often seek out the ram and compete for attention.

The average interval between oestrus periods is 17 days.

A. Effects of shearing and cold stress

Shearing often coincides with mating with second shear policies. If ewes are shorn just prior to putting the rams out they may stop oestrus cycling for about three weeks. Although ewes still ovulate they may fail to show oestrus behaviour and are therefore not mated (MacKenzie *et al.*, 1975). This can show as a "gap" in lambing.

Shearing may stop ewes cycling and should be avoided from two weeks before until two weeks after mating.

Avoid shearing from two weeks before mating until two weeks after the end of mating to prevent suppression of oestrus or poor embryo implantation.

B. Age of the ewe

Young ewes (hoggets and maiden two tooths) have shorter oestrus and weaker libido and thus less time in which to mate. They may fail to compete if mated in the same mob as older ewes (Smith, 1982) so should be mated separately.

C. Hogget oestrus and hogget lambing

Puberty is more closely related to hogget weight than age. Hoggets grown rapidly are likely to show first oestrus earlier. Age and live weight at puberty vary both between and within breeds. Ewes of the more fecund breeds (e.g. Finn) tend to reach puberty earlier and at lighter live weights than less fecund breeds (e.g. Romney-based). Ewes born and reared as twins may also reach puberty at a similar age to single lambs but up to 3 kg lighter (Hight *et al.*, 1973).

Ewes which reach puberty early and lamb as hoggets tend to show higher reproductive performance over their lifetime. They have more lambs as two tooths than those that did not show hogget oestrus (Moore and Hockey, 1982).

Ewe hoggets which show oestrus have a higher lifetime reproductive performance than those which don't.

Ewes which showed hogget oestrus have more lambs and less barrenness in successive years (Hight and Jury, 1976; Meyer, 1981). These effects may result in an additional 7.7 lambs born per 100 ewes mated and accrue to 23 additional lambs per 100 ewes over three lambings (Meyer, 1981).

Hogget lambing is highly effective if they are well grown to reach puberty and well fed throughout pregnancy and lactation to reach acceptable two tooth mating weights. As a general rule hoggets should be close to 40 kg live weight at mating and joined with the ram at least one cycle later than for ewe mating.

Ovulation rate

High ovulation rate is the obvious first step in achieving high lambing percentage. Table 5 demonstrates the expected litter size according to ovulation rate.

A high ovulation rate (O/R) is the first step in achieving a high lambing percentage.

Table 5: Ovulation rate, resulting litter size and percentage of singles and multiples (adapted from Hanrahan, 1982)

		Percentage			
Ovulation rate	**Litter size of those that lamb**	**Singles**	**Twins**	**Triplets**	**Quads**
1	1	100			
2	1.7	30	70		
3	2.3	16	44	41	
4	2.7	11	31	39	19

A 10% increase in ovulation rate typically causes:

6.9% more lambs born per ewe lambing and
5.7% more lambs docked per ewe mated.

Increases in lamb drop above 170% are mainly due to more triplets and less singles.

A 170% lamb drop would have about 3% of ewes with triplets but increases in lambing above this are mostly due to more triplets and fewer singles. The proportion of triplet and quadruplet litters is likely to exceed 15% when lamb drop reaches 190% (Davis *et al.*, 1983). A lamb drop of 200% may comprise 20% singles, 60% twins and 20% triplets.

A. Effect of ewe live weight

Live weight has two effects:

• **The static (live weight) effect**

Heavy ewes have higher ovulation rates (and more lambs) than light ewes. Twinning (percentage of twin births to total births) increases by about 6% per 4.5 kg increase in ewe live weight — i.e. 1.3% per kg increase (Coop, 1962; Coop 1966). This effect operates up to at least 70 kg live weight and there is no evidence of a decline at the top end of this range (Allison, 1982). Barrenness increases markedly under average weight of 40–45 kg for Romney-based breeds (Hight and Jury, 1973) and 35–40 kg in Merinos.

High ewe live weight and live weight gain during mating causes high O/R - for each extra kg of ewe weight there will be 1.3% higher lambing percentage.

Comparisons of poorly-reared and well-reared ewes show that while the poorly reared ewes have fewer multiple ovulations, this is probably a function of their lower adult live weight (Smeaton *et al.*, 1982).

• **The dynamic (live weight gain or "flushing") effect**

Some trials have shown ewes gaining weight quickly (e.g. 0.5–1.0 kg per week) just before mating had higher ovulation rates than ewes of similar weight with low or no weight gain (Rattray *et al.*, 1983; Smith 1991). However the results of Thompson *et al* (1990) (see p.26) showed that ovulation rate was more dependent on ewe live weight at oestrus than on previous changes.

Underfeeding

Underfeeding just before or during mating reduces ovulation rate due to lower live weight. Moderate undernutrition does not appear to affect other reproductive factors such as incidence of oestrus, mating behaviour or fertilisation rate (Braden, 1971).

Underfeeding just before and during mating will reduce O/R.

B. Effect of ewe age

Ovulation rate generally increases from puberty to peak at about four years old. This level is maintained for several years then declines in old age. Useful breeding life (in terms of ovulation rate and overall lambing percentage) may last to at least eight or nine years old (Hickey, 1960). Table 6 shows that the lambing performance of old ewes is eventually offset by high ewe deaths. (Note that "lambing percentage" refers to lambs tailed divided by ewes mated, so deaths of old ewes are accounted for in the lambing percentage figures.)

Table 6: Mortality and breeding performance of different aged ewes (adapted from Hickey, 1960).

Ewe age (years)	Cumulative Death rate (%)	Lambing percentage(%)
1.5	3.0	78.2
2.5	4.4	94.4
3.5	6.0	96.8
4.5	8.6	109.2
5.5	12.8	108.6
6.5	18.0	100.4
7.5	25.5	93.6
8.5	37.2	91.8
9.5	52.5	86.6
10.5	75.3	84.2

C. Major genes affecting ovulation rate

There are two major "fecundity genes" presently identified in New Zealand, the Booroola gene (Fec^B) and the Inverdale gene ($FecX^I$).

Booroola gene

The Booroola gene was discovered in prolific Merinos. Each copy of the gene has an additive effect on ovulation rate — i.e., if ewes with no Booroola gene shed 1 egg per ovulation then ewes with one copy (heterozygous ewes) will shed about 2.5 eggs and ewes with two copies of the gene (homozygous ewes) will shed about 4.0 eggs. The extra 1.5 eggs from heterozygous ewes results in an increase in litter size of 1.0.

Although commercially available and well known for many years, there has been little use of the Booroola gene in commercial flocks.

> ***Major genes affecting O/R include the Booroola and Inverdale. Ewes with these genes have higher O/R by 1-3 eggs (homozygous Inverdale ewes are infertile).***

Inverdale gene

The Inverdale gene was discovered in an Invermay flock selected for prolificacy. It is found on the X-chromosome, so a ram carrying $FecX^I$ passes the gene on to all of his daughters and none of his sons. A ewe with one copy of the gene passes it on to half of her offspring of either sex.

A single copy increases ovulation rate by about 1.0 egg per ovulation and litter size by about 0.6. There appear to be no direct effects on rate of barrenness, embryonic mortality or lamb mortality (although both of the latter increase in line with higher litter sizes, as normal).

Homozygous ewes ($FecX^I$/ $FecX^I$) are infertile and have small non-functional streak ovaries. These can be seen with a laparoscope from two months of age. Ram lambs can therefore be progeny tested for the $FecX^I$ gene by mating them to known $FecX^I$ ewes — if they have the gene, half of their daughters will show streak ovaries. The Inverdale gene has potential where ewes are mated to terminal sires.

D. Breed effects

Many farmers believe inherently low fecundity in the Merino accounts for low performance on high country. Merino ovulation rates are only slightly lower than for similar size ewes of Romney-based breeds but lambing percentage improves dramatically when Merino ewes are well fed (see variation in pregnancy scanning results for Merinos p.20).

There is breed variation in average O/R with Merinos at the lower end of the scale, crossbreds in the middle and Finns highest with potential lamb drops over 200%.

The Finn is highly fecund and was imported for this trait. Lamb drops in quarantine exceeded 200% with litters of four lambs quite common. While few farmers run pure Finns, the number of ½ and ¼ Finn ewes continues to increase. Hogget mating of ½ Finn ewes is common, with a lambing of 100% as hoggets and 150% as two tooths achievable with good management. Although the ¼ Finn is theoretically expected to increase average lambing percentage by about 25–30%, many farmers have found increases of only 10–20% and some have not achieved 10% (Cook, 1996). This may reflect unreasonable expectations of the Finn and failure to overcome feeding and management deficiencies that caused low performance prior to using the Finn.

Genetic increases in litter size appear to be mostly due to higher ovulation rate (Meyer and Clarke, 1982). There is no evidence that selection for increased litter size has increased "uterine efficiency" — i.e. efficiency of producing lambs from the number of eggs shed — either within or between breeds. With most sheep breeds (Romney, Coopworth, Perendale and Corriedale) there is greater variation in ovulation rate within than between breeds.

There is large variation in O/R within breeds.

Since ovulation rate and reproductive performance are moderately heritable, steady genetic progress can be made. Selected prolific strains (e.g. Ruakura fertility lines, Waihora Romneys) are evidence of this where up to 2% per year improvement in lambing percentage has occured. Selection for increased lambing percentage on commercial farms is usually done by selecting ewe replacements from twin ewe lambs.

Crossbreeding can be used to introduce high fertility genes and will give up to 20% increase in O/R in addition to the breed genetic gain.

Crossbreeding can be used to introduce more fecund breeds (e.g., the Finn), introduce special genes (e.g., the Booroola) or to utilise heterosis (hybrid vigour). Heterosis is extra performance achieved above the expected average of the parent breeds. Heterosis is usually most pronounced in traits that are relatively slow to respond to selection, including several reproductive performance traits, as shown below:

Table 7: General estimates of heterosis for reproductive traits (Dalton, 1980).

Trait	Heterosis (percentage response)
Barrenness (hybrids less barren)	18
Lambs born per ewe lambing	19–20
Lambs weaned per ewe joined	60
Lamb survival	10–15
Lamb birth weight	6

E. Latitude effects

In practice, farmers in the south generally expect about 5–10 more lambs per 100 ewes mated than ewes of similar genetic background and mating live weight would achieve in the north. These results appear to be related to latitude and there are no practical steps North Island farmers can take to make up the difference. Cooler temperatures in southern regions are thought to help, causing lower plant and animal pest levels and correspondingly better feed quality and animal health.

Examples of this are ovulation rates of 1.4–1.6 in Otago Romney ewes compared with previously measured ovulation rates of 1.2–1.3 in North Island ewes (Averill, 1964). While Northland and Poverty Bay ovulation rates would result in theoretical lambing percentages of 90–112%, Otago/Southland farmers could expect 112–133%, assuming losses of 40 eggs per 100 from ovulation to tailing (Averill, 1964).

F. Immunisation against hormones for higher ovulation rate

Vaccinating ewes to produce antibodies against some of their own hormones can increase ovulation rates. A commercial product available for this is Androvax™.

Androvax™ trials show an average increase in ovulation rate of 59 eggs per 100 ewes treated and 24% (range 11–56%) increase in lambing percentage. Results reported by commercial farmers vary from -26% to +58% (as detailed in Androvax™ promotional material).

Vaccines (eg Androvax) which immunise ewes against some of their own hormones can increase O/R by up to 58%.

Treatment must be given each year and can be combined with other vaccinations. In the first year two doses are given at eight and four weeks before mating. *If mating is within 2–3 weeks of the second treatment increases in barrenness occur, so timing is very important.* In subsequent years, ewes need only one dose four weeks before mating.

Farmers considering use of Androvax™ must assess their ability to suddenly rear about 20% more lambs. Most increases in lambing percentage happen more gradually and farmers can adjust management to suit over several years. These products are not a treatment for low ovulation rates caused by poor ewe feeding. Preferential feeding of the multiple-bearing ewes during pregnancy is important in achieving good lamb survival.

Androvax™ is not suitable for commercial flocks with lambing percentages under 100% nor for those with over about 150% (as there are likely to be many more triplets). In flocks achieving 170% or more a high proportion of ewes will have three or more lambs.

Treatments with Androvax™may be useful in improving reproductive performance from ewes lambing out of season. Ovulation rates are usually lower for hormonally induced out of season breeding but immunisation may lift performance back to more normal levels.

Seasonality of ovulation and ovulation rate

Most sheep breeds are seasonal breeders and fewer eggs are shed in the first cycles of the breeding season in early autumn. The first cycle of each season features a "silent heat" — i.e. ewes ovulate but do not show oestrus. Highest lambing percentage coincides with mating mid-season — i.e. about April, depending on location. Higher numbers of abnormal eggs may be shed near the beginning and end of the breeding season (Quinlivan and Martin, 1971).

Ewe breeding season is normally from early to late autumn (February to May) and starts with a 'silent' cycle (ovulation without oestrus).

Thompson *et al* (1990) showed that ewes had 0.15 more eggs shed at each progressive oestrus during three successive cycles. Ewes should therefore be mated at their second or third oestrus for maximum lamb numbers.

Each successive ewe oestrus during the breeding season has about 0.15 more eggs shed.

Breed effects on seasonality

Breed effects are important in seasonality. The Dorset (polled and horned) is much less seasonal than Romney-based breeds and many successfully lamb in autumn without hormonal treatment. Selection to develop a flock capable of lambing naturally in autumn (using only the "ram effect") can be done by culling those that fail to breed out of season and keeping autumn-born ewe lambs as replacements (McQueen and Reid, 1988).

Breeds such as Dorsets (polled or horned) and Merinos have a longer breeding season than crossbreds.

The Merino has an extended breeding season and in Australia is routinely mated from about October to December. The New Zealand Merino has a slightly longer breeding season than Romney-based breeds (Smith *et al.*, 1989).

Synchronisation

Synchronisation may be used to get ewes ovulating simultaneously (e.g. to facilitate timing of artificial insemination) and/or to induce ewes to cycle out of season. The two ways of doing this are by using rams or hormonal treatment.

A. Use of rams ("ram effect")

The introduction of rams early in the breeding season stimulates ewes to ovulate within 3–6 days (without showing oestrus if this is the first ovulation of the breeding season) and show oestrus about 17 days later (Schinkel, 1954). Ewe flocks stimulated by the ram effect are thus likely to be synchronised. Rams introduced several weeks before normal onset of oestrus may have no effect and late introduction will only stimulate those few ewes which have not begun cycling.

Synchronisation can be used to get ewes ovulating simultaneously by using hormones or rams.

Rams used for synchronisation may be entire or vasectomised. Some poor results with rams vasectomised for one year or longer have been reported (Edgar and Bilkey, 1963) and this may be due to reduced libido in these rams. High libido vasectomised rams are most effective and should be introduced up to a week before normal if using as teasers (i.e. to stimulate ovulation and oestrus).

Rams introduced early in the breeding season, either vasectomised or entire, will stimulate ewes to ovulate within 3-6 days.

Some breeds are more effective, with Dorset rams usually superior to Romneys.

B. Hormonal synchronisation

Hormonal synchronisation can be used to:

- stimulate first oestrus (e.g. first oestrus in hoggets or an early first oestrus for older ewes)
- synchronise ewes to show oestrus at the same time (e.g. to condense lambing or for artificial insemination) during the normal breeding season

Use of hormones involves CIDR sponges with progestagens inserted into the vagina so ewes will ovulate after withdrawl.

"Controlled internal drug releasers" (CIDRs) or sponges containing progestagens (synthetic analogues of progesterone) are most commonly used. Results are more heavily influenced by operator skill and timing of insemination than product type. The CIDR or sponge is inserted in the vagina and withdrawn after several days. The ewe typically shows oestrus within three days after withdrawal when CIDRs are used within the normal breeding season. This time varies depending on dose level of progestagen, type of device or sponge used and whether pregnant mare's serum gonadotropin (PMSG) is also used to stimulate greater ovulation rate. Ewes not fertilised at this oestrus will return to oestrus about 16–17 days later and remain generally synchronised. This is useful when planning a return visit for an AI technician.

Synchronisation for out of season breeding usually requires PMSG also to stimulate ovulation.

Prostaglandin injections can also be used for synchronisation but are not common. Ask your vet about synchronisation or hormonally induced oestrus if planning to use it for the first time.

C. Out of season mating

Slightly earlier breeding can be achieved using the "ram effect" but farmers lambing ewes out of season must use CIDRs and PMSG (Smith *et al.*, 1988b; Knight *et al.*, 1989). Good management is essential to ensure ewes are in oestrus with high ovulation rates and thus good potential lambing percentage. Even then ewes lambing out of season do not usually achieve lambing percentages comparable to those during their normal breeding season.

Melatonin implants

The pituitary hormone melatonin can be used as an implant to regulate the breeding season.

Melatonin is a pituitary hormone involved in the regulation of the breeding season in response to changes in day length. Manipulating melatonin levels (e.g., with implants such as Regulin®)can alter ewe breeding performance out of season. Responses depend on applying the implant at the time when the ewe is receptive to the effect of short days — timing of application and mating are very important. Seek veterinary advice for more detail about the use of melatonin implants.

Internal parasites

Internal parasites (worms) are not usually a problem in ewes at mating and drenching is not generally recommended. However, it is important to establish that internal parasites are not limiting ewe weight gains pre mating, particularly in young ewes. Check worm burdens by faecal egg counting in consultation with your veterinarian.

Worms are not normally a problem with ewes at mating time but checking faecal egg counts prior to mating, particularly with young ewes, may be warranted.

Trace elements

Various trace elements may cause problems during mating in different regions. Check with your veterinarian for a guide to likely local deficiencies and suitable products for overcoming these. Selenium and iodine are presented here as examples.

Selenium

Selenium-responsive infertility is likely in areas where congenital white muscle disease occurs (Millar, 1983). Conception rates may be normal but high embryonic loss to about day 30 of pregnancy occurs if ewe blood selenium level is below 10 mg/ml. These losses are manifest as dry ewes at pregnancy scanning. Such embryonic losses are prevented by treating ewes with selenium before mating.

Selenium should be routinely administered pre mating in deficient areas.

Check with your veterinarian before supplementing with selenium. Supplementation has no benefits if levels are adequate and excessive selenium is toxic.

Iodine

Iodine deficiency of ewes, especially at sub-clinical levels, has been suggested as a widespread reason for reduced reproductive performance mainly due to poorer lamb survival. Table 8 shows lambing percentage responses to a single injection of Lipiodol® at least six weeks before mating or in mid pregnancy (McGowan, 1983).

Table 8: Changes in lambing performance for ewes treated with Lipiodol® (McGowan, 1983)

Locality	Treatment timing	No. ewes treated	Improvement in % of lambs	
			born	docked/ weaned
Sth Auckland	pre-mate	278	not recorded	9
Wairarapa	pre-mate	100	18	8
Sth Canterbury	pre-mate	159	10	10
Manawatu	mid pregnancy	115	5	4
Sth Canty Yr 1	mid pregnancy	213	0	not recorded
Yr 2		149	21	17
Yr 3		69	23	20

Responses to iodine varied. Wairarapa ewes treated three weeks pre-mating showed elevated thyroxine levels but no advantage over the control flock for iambing performance, lamb growth rate or ewe fleece production (Parker and McCutcheon, 1989). Iodine may not have been limiting in the Wairarapa ewes.

Iodine deficiency can suppress lambing percentage so levels should be checked.

These results demonstrate the need to establish the existence of a deficiency before expecting treatment to show benefits. Blood testing is generally reliable for important trace elements such as selenium but elevated lamb thyroid gland weights are the best indicator of iodine deficiency (Mulvaney, 1997). A lamb thyroid gland weight (g) to lamb weight (kg) ratio of 0.4 or greater indicates iodine deficiency. Iodine can be administered as an injection of Lipiodol® or orally as potassium iodide.

Toxins

Facial eczema

Facial eczema (FE) disease is caused by ingesting the fungus *Pithomyces chartarum*. Spores of *P. chartarum* contain a toxic compound, sporidesmin, which causes liver damage, sensitivity to sunlight and decreased animal performance. FE commonly occurs in late summer/autumn in warm humid regions of the North Island. The incidence generally drops further south and FE is virtually unknown in most parts of the South Island.

Ewes exposed to high pasture spore counts at Whatawhata Research Station showed 2–3% more barrenness and 5–7% fewer multiple births for every 100 i.u. increase in serum GGT levels (Sheath *et al.,* 1987). (GGT is an enzyme which indicates liver damage, as caused by facial eczema.) Up to 17% of the flock either died from clinical FE, were barren or were culled.

Facial eczema (FE) caused by a pasture fungus can suppress lambing percentage through increased barrenness and fewer multiples.

Early exposure to FE may penalise lifetime performance due to permanent liver damage. Hoggets with high GGT levels (>350 i.u./l) subsequently showed lower fertility (i.e. number of ewes lambing/number of ewes mated) at all matings over the next four seasons compared with hoggets with lower GGT levels but the effect was only statistically significant ($p<0.05$) at hogget and two tooth mating (Moore *et al.*, 1990).

Management options to reduce FE effects include:

- spore counting to identify safer parts of the farm. Spore counts may be lower on southerly facing slopes and on some pasture types.
- lax grazing if ewes must graze pastures with high spore counts
- planning grazing management to make crops and safer parts of the farm available to ewes around mating
- zinc dosing if pasture spore counts are high on grazed pasture
- fungicide spraying of pastures on easy country
- long term breeding for resistance to FE and use of FE tested rams on commercial farms

Effects of FE can be minimised by preventive grazing management, zinc dosing or breeding for resistance.

Breeding for FE resistance

Some stud breeders who supply rams to FE-affected areas are breeding for resistance. Ram lambs are dosed with sporidesmin and blood GGT levels are measured to indicate severity of liver damage and thus resistance or susceptibility to FE. Resistance is quite highly heritable so progress can be rapid with selection. Some stud breeders resist testing ram lambs because live weight gain can be affected and susceptible ram lambs may be unsaleable.

B. Zearalenone

Zearalenone is a toxin produced by a range of *Fusarium* fungi in pasture. Its effects are similar to oestrogen, reducing ewe fertility and fecundity. Rams appear not to be affected. *Fusaria* and the zearalenone toxin occur throughout New Zealand.

Fusaria generally grow on dead material in pasture rather than on green leaf. Growth is greatest in late summer and autumn, with spore formation under warm dry conditions. Zearalenone level does not always follow the pattern of spore production in the pasture so spore counting (as done for FE) is not helpful. High zearalenone levels occur under a wide range of weather conditions and "problem times" are hard to predict.

The toxin zearalenone from a pasture fungus can reduce ewe fertility and fecundity.

Intake of zearalenone before mating affects oestrus behaviour (decreased cycle length, increased oestrus duration), and decreases ovulation and fertilisation rates Towers, 1992). The number of barren ewes increases and fewer ewes have multiples. Zearalenone exposure after mating does not appear to affect pregnancy rate or embryonic loss.

Ovulation rate (and lambing percentage) falls by about 5% for every mg of zearalenone ingested per day for short term exposures and about twice this rate if exposure is prolonged (Towers, 1992). Thus the minimum toxic dose for short exposure (10–15 days) is very low at about 1 mg per day and even lower for exposure over 20 days.

Suspect zearalenone effects if lambing performance appears inconsistent with ewe mating weights and no other obvious problems (e.g. ram infertility, abortion) can be found. Pasture zearalenone levels can be measured and related to reproductive performance, as can metabolites in ewe blood and urine.

Tests for zearalenone levels are best done using ewe urine samples.

Pasture tests can indicate zearalenone presence but sheep urine testing provides the best indicator as urine zearalenol (a metabolite of zearalenone) increases with zearalenone intake. Urine samples should be collected from 12–15 ewes and bulked together with an equal quantity from each ewe (0.5 to 1 ml) for a single test. Blood zearalenol levels are poorly related to zearalenone intake and are not helpful.

All testing is done by AgResearch at Ruakura and should be in conjunction with a veterinarian for instructions.

There is no treatment or vaccination for zearalenone effects and resistance to FE does not confer resistance to zearalenone (Smith *et al.*, 1988a). If there are some ewes that perform well in spite of exposure to zearalenone, there may be scope to select for genetic resistance to zearalenone.

C. Phyto-oestrogens

Some pasture legumes such as red clover, subterranean clover and lucerne contain compounds that mimic natural oestrogen. Levels of these compounds rise if plants are damaged (e.g. by insect pests). A few plants in mixed pastures do not cause problems but grazing pure stands can decrease ovulation rate. Ewes flushed on oestrogenic lucerne have shown ovulation rate decline of 30% compared with similar weight ewes on grass dominant pasture (Smith, 1982). New, non-oestrogenic red clovers are available.

> ***Phyto-oestrogens produced by plants such as red clover, subterranean clover and lucerne can decrease ovulation rate by up to 30%.***

Conservation as hay reduces the oestrogenic effect but does not remove it entirely. Lucerne silage may be more potent than the plants from which it was made.

The effects of short term exposure are temporary and can be overcome by grazing ewes on non-oestrogenic pastures for 14 days before mating. Effects of four weeks grazing on oestrogenic red clover may be overcome within as little as one week on non-oestrogenic pasture (Anwar *et al.*, 1994). Temporary effects of lucerne grazing can be overcome by a short period (7–14 days) of grass feeding before mating.

However, long term exposure to oestrogenic pastures can lead to permanent infertility (Shackell *et al.*, 1993a). Compared with ewes grazing ryegrass-white clover swards, those grazing pasture with 60+% red clover for 6 months before mating showed:

- small depressions in ovulation rate (not significant at $p<0.05$) although the ewes on red clover were 3–6 kg heavier
- similar proportions of ewes marked by rams in the first cycle
- 30% more returns to service
- more barren ewes (up to 62% barren, typically 34–48%). Ewes on 30% red clover also showed higher barrenness (7–17% barren) than those on ryegrass-white clover (5–9%).
- 0.5 fewer lambs born per ewe mated
- more vaginal prolapse (bearings)
- 82% more deaths over the six year study

Ewes still ovulate and show oestrus but do not conceive. This is thought to be caused by changes in cervical mucus impeding sperm passage and preventing fertilisation. Ewes exposed to red clover long-term also show vaginal abnormalities (Shackell *et al.*, 1993b).

Pure stands of oestrogenic plants should be avoided around mating time.

There is no treatment or vaccine to prevent the effects of phyto-oestrogenic compounds so, although they are high quality feeds, red clover and lucerne may be unsuitable around mating. Given the risks of permanent infertility, it is best to avoid oestrogenic pastures for breeding females (including ewe lambs and hoggets) as much as possible.

D. Endophyte

Ryegrass endophyte is a seed-borne fungus found in some perennial ryegrass cultivars. While endophyte confers plant resistance to Argentine stem weevil, high levels can lead to ryegrass staggers in stock.

High endophyte ryegrass pastures can suppress lambing percentage so should not be used around mating time.

Staggers may disrupt mating activity and hence reduce conception rates. High endophyte ryegrass pastures should be avoided and alternative pasture species or supplements used at mating. If high endophyte pasture cannot be avoided they should be grazed lightly.

Farmers in areas with minimal Argentine stem weevil should not include high endophyte ryegrass in pasture seed mixes.

The ram

Using harnesses

Ram harnesses are useful to:

- prove ram activity (especially in single-sire mating)
- identify ewes returning to service
- indicate expected lambing dates and spread of lambing

Frequency of crayon colour change depends on the reason for using harnesses but changes every 7–10 days are most useful to indicate lambing dates. Introducing harnesses after 17 days of mating avoids marking the ewes that conceive in the first cycle, reducing the amount of wool marked by crayon.

Ram harnesses can be used to identify the timing of ewes mated and expected spread of lambing.

Well-fitted harnesses do not interfere with ability to mate or reduce ram effectiveness. Check harnessed rams daily, especially in rougher scrubby paddocks.

Feed supplements

Rams often lose considerable weight over mating, especially at high ewe:ram ratios and if feed is limited. Rams may also lose up to 20% of their testicular volume during mating (Hannan and Thwaites, 1994). Since sperm output per unit weight of testes is relatively constant, it tends to decline over mating. Changes in testicular volume occur faster than changes in live weight and body condition.

High protein feed supplements can be used for preparation of rams for mating if high quality pasture is limited.

High quality feed supplements for rams before mating can improve testicular volume. Peas or other high quality and high protein supplements are suitable. Supplementary feeding of rams is uncommon in New Zealand but may be worthwhile with high ewe:ram ratios.

Ewe:ram ratios

Most farmers mate at least 100 ewes per ram to make maximum use of the genetic gain from each ram. As the number of ewes per ram increases, the total number of mounts and services per ram increases but the number of services per ewe declines. However, even at ratios of 210 ewes per ram, the proportion of ewes mated in each cycle is unchanged (Allison, 1975b), so long as the rams were in good body condition with good teste size.

Ram fighting increases considerably at less than 30 ewes per ram. At more than 100 ewes per ram, ewes may compete for rams with jostling and pushing which disrupts services (Fowler, 1983). Rams have been observed to mate more than 300 ewes in a cycle when mated at ratios of 210 ewes per ram (Allison, 1975b).

Ewe to ram ratios can be as high as 100 to 200:1 with mixed age ewes and rams in good condition.

However, as the number of services and mounts per ewe falls, flock fertility may decline. Losses of fertilised eggs appear to be higher in ewes served once compared with those served twice or more (Fowler, 1983).

These effects are unlikely to be important in typical flocks mated at 100–150:1 but could become limiting with very high ewe ratios (e.g. 400:1). However, high ratios (e.g. 200–300:1), for at least one cycle of mating, remain an efficient way of using rams and of getting good value from expensive rams without artificial insemination.

Choose appropriate ratios according to ewe and ram age — e.g., 100:1 for ewe hoggets, 150:1 for older ewes. Do not mate ewe hoggets in the same mob as older ewes.

Ewe to ram ratios should be 100:1 or less with ewe or ram hoggets.

Artificial insemination

The use of artificial insemination (AI) in sheep has gradually increased. Initially AI was used in ram breeding flocks to introduce high value rams and for sire referencing, but now it has spread to commercial flocks. AI is now used to introduce new breeds such as the East Friesian before rams are widely available.

Conception rates are usually lower than for natural mating with 65–70% regarded as a reasonable commercial result and over 75% excellent. Rates are higher for intra-uterine (laproscopic) than cervical inseminations.

Originally artificial insemination was used mainly in ram breeding flocks and more recently in commercial flocks for introduction of new breeds.

Success is influenced by factors such as:

- *identification of ovulating ewes.*
  Failure to correctly identify ewes in oestrus for good timing of insemination reduces conception rate. Cycling ewes can be identified using harnessed vasectomised rams.
- *cervical insemination versus intra-uterine insemination.*
  Intra-uterine insemination gives conception rates about 10 percentage points higher than for cervical — e.g. operators might guarantee non-return rates (i.e. conception rates) of 60% and 50% for intra-uterine and cervical insemination respectively. Cervical insemination needs to be well timed in relation to ovulation whereas intra-uterine is more flexible. Farmers can be trained for cervical insemination, but only a veterinarian can carry out intra-uterine insemination using laproscopy.
- *frozen versus fresh semen.*
  Fresh semen must be used within 24 hours and frozen semen is preferable if this cannot be guaranteed. Freezing is common and the technology is well developed, but it is only suitable for intra-uterine insemination.

- *technician skill.*
  There is no substitute for skill and cost-cutting may lead to poor results. Skilled operators are becoming more common and farmers using AI for the first time should ask their veterinarian to recommend a technician.

Either fresh or frozen semen can be used successfully by a skilled operator.

Conception failure

Conception failures are seen as "dry-dry" ewes. Such ewes should generally be culled (although dry-dry hoggets and sometimes two tooths are kept).

Failure to mate

The number of commercial ewes which fail to mate is generally low. Over three cycles of mating, typically 0–3% of ewes fail to mate (Kelly 1982) and this is higher if ewes are synchronised or mated out of season. Most failures are overcome by being mated at the next cycle.

Failure to mate can include up to 3% of ewes and can be minimised by high ewe live weight and condition, good ram preparation and appropriate ewe:ram ratios.

Important factors in minimising failures to mate are:

- adequate ewe live weights
- healthy active rams
- ewes not isolated from rams — e.g. by paddock topography or size, bush or scrub, ridges, deep gullies, partially removed fencelines
- good availability of feed — when feed is scarce the flock disperses to search for feed, decreasing the number of ewe:ram contacts
- lower ewe:ram ratios with young ewes
- enough rams to cope with synchronised ewes if necessary

Heavy rain can interrupt mating behaviour for one to two days but there is little farmers can do about this (Fowler, 1983).

Fertilisation failure

Failure of fertilisation (measured by returns to service) has been around 0–15% in individual experimental flocks (Allison, 1975a; Allison, 1975b) and a maximum of 5–20% (Kelly, 1980). When ewes shed two or more eggs, usually all or none are fertilised rather than a proportion (Kelly, 1980).

Most fertilisation failures are overcome by returns to service as most ewes have a second or even third opportunity to conceive in any mating period. However, this may not occur in flocks mated late in the season where many ewes may not be first mated until their last cycle for the season (Kelly, 1980).

Fertilisation failure can be due to poor ram preparation and/or stresses during mating such as excessive yarding, shearing or flystrike.

Fertilisation failures are higher for single-sire mating, artificial insemination, when ewes are synchronised and when mating out of season. Ram harnesses are useful to indicate returns to service in single-sire mated flocks where fertilisation failures may lead to low or nil lambing percentages. A ram with high returns can be replaced before it is too late.

Failures should not be a problem if:

- rams are healthy, in good condition and brucellosis free
- several rams are used in each flock so ewes are mated by two or more rams
- stresses are minimised — e.g., yarding, shearing, flystrike

Embryonic and placental development

In early pregnancy the embryo implants into the lining of the uterus and the placenta begins to develop. During implantation, 12-14 days after fertilisation, embryos are vulnerable and some or all of multiple conceptions may be lost.

Development of the placenta is very important as it affects lamb birth weight. Small lambs are especially susceptible to starvation/exposure soon after birth while very large lambs may result in dystocia. See Chapter 5 for more discussion about the importance of lamb birth weight and implications for lamb survival.

Embryonic loss

Embryo death in early pregnancy is a major contributor to reproductive wastage with typically 20–30% of fertilised eggs lost (Edey, 1977; Quinlivan *et al.*, 1966; Smith, 1982). Most concern centres on "partial failure of multiple ovulations" or the loss of one or more embryos from several fertilised eggs. Multiples are more likely to be lost (Quinlivan *et al.*, 1966; Kelly 1980) and birth weights of surviving lambs are often lower when sibling embryos have been lost (Rhind *et al.*, 1980). Embryonic loss is higher in hoggets than two tooths or older ewes (Kelly, 1980), although it may also be high in ewes over eight years old (Smith, 1982).

Embryonic losses in early pregnancy commonly reach 20-30% of fertilised eggs and most losses are in multiple ovulations.

Suggested causes of embryonic loss include:

- chromosomal abnormality. The death of lambs with severe chromosomal abnormalities is desirable in many cases, as such lambs carried to term would die at birth or soon after.

- selenium deficiency
- severe underfeeding of ewes
- stress such as shearing in bad weather. It appears that stress must be frequent or severe to have large effects but minor stresses such as yarding and handling should be kept to a minimum.
- disease such as Hairy Shaker disease increases embryonic and later foetal loss but is probably under-diagnosed. Other disease agents (not yet identified) may have similar effects. There are no treatments for these.
- extreme high temperatures (unlikely to be a problem in New Zealand)

Causes of embryonic loss include genetic abnormality, diseases such as Hairy Shaker, mineral deficiencies or hormonal imbalances.

There is very little farmers can do to reduce embryonic losses apart from feeding ewes well and minimising stress during mating-early pregnancy.

Ewe nutrition and placental development

Placental development is strongly linked to lamb birth weight. Underfeeding can reduce cotyledon numbers and development, thus reducing the transfer of nutrients from the ewe to the lamb (Dingwall *et al.*, 1987) and causing lower lamb birth weights.

Placental development between days 30 and 90 of pregnancy is linked to lamb birth weight.

The major factors affecting foetal growth are ewe nutrition and the size of the placenta. Ewes should be fed to maintain good mating body condition in early pregnancy to ensure adequate early placental development.

These effects extend into mid pregnancy (see Chapter 4). If ewes lose about 5 kg in the first 90 days of pregnancy placental development and multiple lamb birth weights will be reduced. Ewes losing more than 12% of their mating live weight up to day 90 of pregnancy may have up to 10% lower lamb birth weights, regardless of late pregnancy nutrition (Rohloff, 1984).

Loss of ewe live weight (5 kg or greater) during early-mid pregnancy will reduce placental development and lamb birth weight causing poorer survival of multiples.

Recent work from Massey University (Cooper, McCutcheon and Morris, unpublished) showed placental weight increased in a near linear way with improved nutrition to day 100 of pregnancy. After feeding ewes at either 0.5 X maintenance (0.5M), 1.0M or 1.5M, placental weight at day 100 was 670g, 718g and 861g, respectively.

Undernutrition

Very poor nutrition in early pregnancy has been shown to reduce the number of ewes lambing in Merinos (Bennett *et al.*, 1964), probably by increasing embryonic loss. Serious losses may appear when live weight at mid pregnancy is 15% lower than mating weight. Moderately poor nutrition may not effect the number of lambs born (Coop and Clark, 1969).

There is evidence that where low lamb numbers are conceived but most ewes are pregnant (i.e. the flock is fertile but almost all ewes have singles), moderately restricted feeding in early pregnancy does not greatly affect survival and lambing percentage (Bennett et al., 1970). The losses of single embryos probably do not occur and any restriction in placental development still results in a sufficiently large lamb.

Ewes need 1.0-1.3 kg of dry matter per day (average to good quality) to hold body condition during mating and early pregnancy.

Poor ewe nutrition in early pregnancy may, however, reduce lamb growth from birth to weaning (Everitt, 1967). This effect disappears by about 18 weeks of age but may be important for farmers wishing to grow lambs quickly for early drafting. Poor nutrition in later pregnancy will further reduce early lamb growth due to restricted udder development and lower milk supply.

Feeding to maintain ewe weight and condition from mating through mid pregnancy encourages good placental development and ensures viable pregnancies become well established, as described earlier. Avoid abrupt changes in feeding level.

Stress

Environmental stresses and cold weather can reduce embryo survival. Repeated stress, such as yarding and handling increases embryonic loss (Doney *et al.*, 1976) through partial or complete loss of embryos. Stressed ewes may lose up to about 30% of potential embryos (compared with 17% for non-stressed ewes).

Commercial farmers usually handle ewes infrequently over this period and may expect minimal losses. However, it is worth keeping stress to a minimum (avoiding shearing and excessive handling) in the first month of pregnancy.

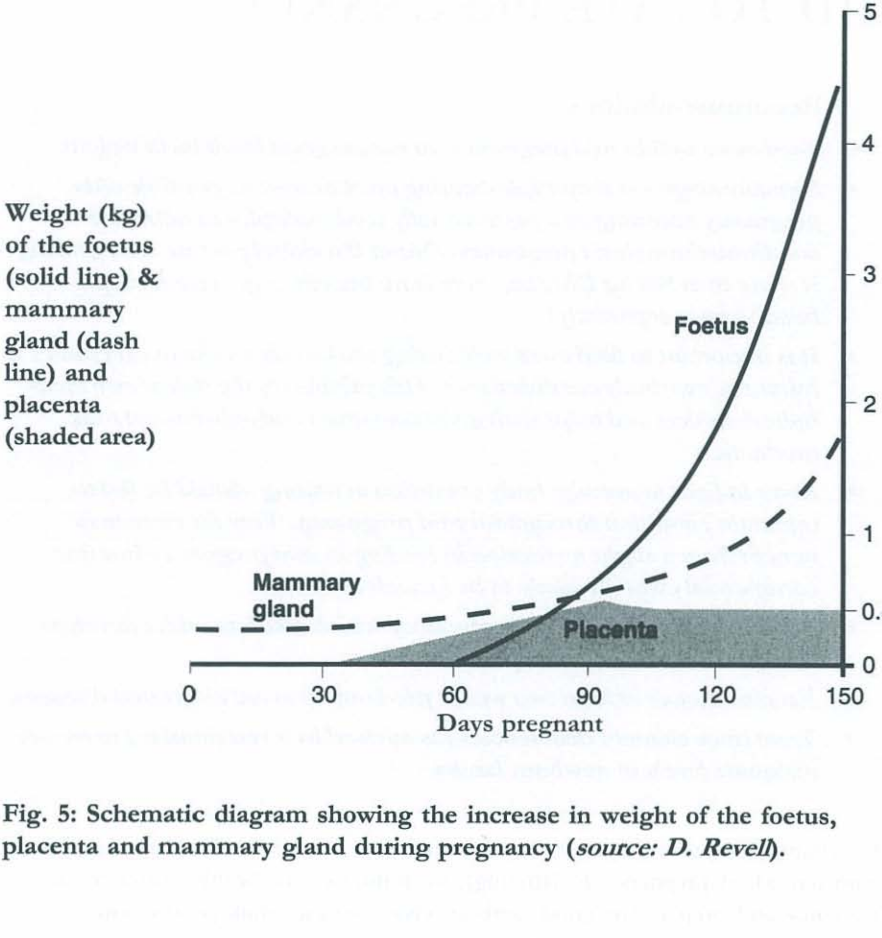

Fig. 5: Schematic diagram showing the increase in weight of the foetus, placenta and mammary gland during pregnancy (*source: D. Revell*).