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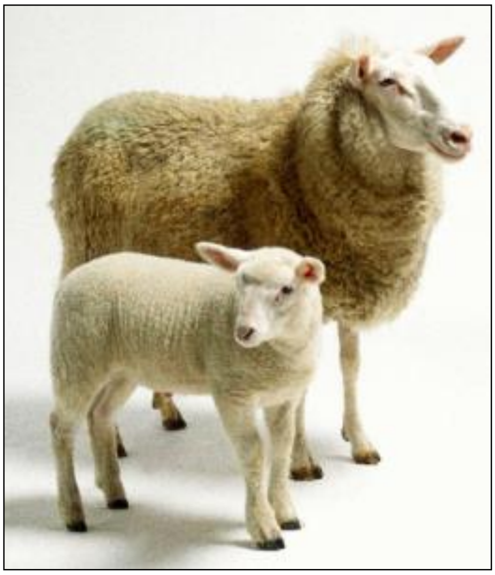
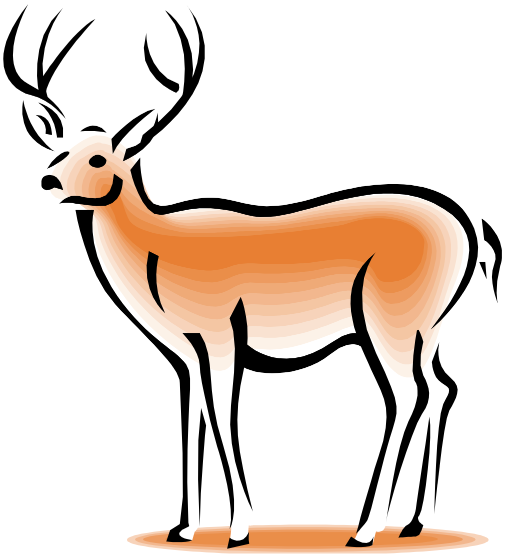
Unit Standard 28971

Animal Husbandry

Describe livestock reproductive processes and practices

Version 2 Level 3 Credit 5





Unit Standard 28971 - Describe livestock reproductive processes and practices. Level 3, Credits 5

Introduction

On any farm that breeds livestock, it is very important that the animals reproduce effectively. Farming practices have a huge effect on the success or otherwise of breeding programmes and manipulation of the reproductive processes can have a major impact on profitability.

Good reproductive management depends on a thorough knowledge of the mechanics of reproduction and the management factors that affect its success on the farm. Animals that fail to get pregnant are generally regarded as a waste of farm resources and are most likely to be culled (to the freezing works) at a convenient time – e.g., after drying off on a dairy farm or as soon as detected on a sheep, deer or beef breeding property.

Reproductive biology

This section mainly describes the normal anatomy and physiology of reproduction **in cattle but also applies to other livestock such as sheep, deer and goats,** and describes the various stages involved in reproduction from conception to weaning.

Reproductive anatomy of the male

Although most mating management centres on getting female livestock to cycle on time and get pregnant, male health and behaviour is also important for reproductive success. This section describes:

- Structure and function of the male reproductive organs and hormones
- Formation and development of the male reproductive system
- Castration and vasectomy to modify reproductive ability
- Normal sexual behaviour
- Abnormal sexual behaviour
- Deformities, abnormalities and animal health problems that can reduce male performance.

Structure and Function of Male Reproductive Organs

Before we can discuss management for successful reproduction, we need to understand the parts of the reproductive system and how they work.

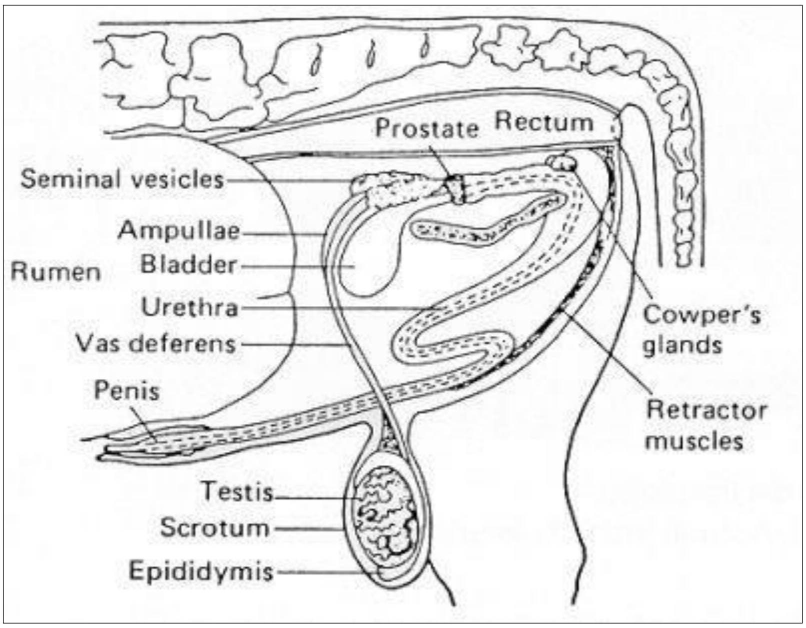


Figure 1 Reproductive tract of the bull

Testes (also called testicles)

These have two important functions:

- Sperm production
- Production of the male hormone testosterone

The mature testes have to produce a huge sperm output because several billion sperm are ejaculated at each mating. The testes contain many long, tiny, coiled tubes called the seminiferous tubules, where the sperm are produced and matured. Specialised cells called Leydig's cells, scattered throughout the testes, produce testosterone.

Sperm collect at the head of the **epididymis** (at the top of each testis) for storage and to become fully mature, ready for ejaculation. The epididymis runs down to the bottom of the testis (the tail of the epididymis), then up to the **vas deferens**. It takes about 45 to 50 days for sperm to be formed and reach maturity.

Testis size indicates serving capacity - i.e., bulls with large testes can generally serve more cows than bulls with smaller ones. You will see this in bull catalogues where breeders usually give the measured scrotal circumference (the length around the testes in the scrotum) for each bull. Most bulls can cope easily with 30 to 40 cows (assuming the cows have not been synchronised but are cycling naturally) but some may be offered 50 or more.

Scrotum

The scrotum is the sac that houses the testes. As well as protecting and covering them, it has a very important function in controlling temperature. The testes are kept 2 to 7 ° C cooler than body temperature – this is essential to keep the sperm cool and viable. Excessive heat can destroy sperm and make the bull infertile; severe cold can also damage the testes.

A muscle contracts to draw the scrotum and testes close to the body when the temperature is cold and relaxes to let them down when conditions are hotter. By observing bulls (or rams) at different temperatures, for example on a cold morning compared to during the heat of the day, you will see this effect.

A stags scrotum unlike bulls and rams does not hang down below the body all year round. It is not noticeable until autumn when the testes enlarge ready for mating.

Epididymis

The epididymis is a coiled tube that is lined with cells to push the sperm along during ejaculation. Its functions are:

- Sperm storage
- Providing a place for sperm to mature
- Secreting a small volume of fluid that contributes to the semen

Vas deferens

The **vas deferens** is the transport tube that takes sperm from the epididymis to the urethra. It passes some important glands along the way, which add the fluids that make up the rest of the semen. The vas deferens from the two testes come together to enter the urethra.

The **spermatic cord** consists of the vas deferens plus the blood vessels and nerves that serve the production and transport of sperm from the testis.

Seminal vesicles and prostate gland

The seminal vesicles are found close to where the vas deferens unite with the urethra. They produce secretions that make up most of the fluid part of semen. The fluid transports the sperm and activates them to become motile (i.e., to actively swim with their tails).

The prostate gland opens into the urethra but is quite poorly developed in the bull and contributes only a small amount of fluid. The seminal vesicles are much more important.

Cowper's glands

The Cowper's glands are found on each side of the urethra. They secrete fluid for neutralising and cleansing the urethra before the semen passes through during ejaculation.

The seminal vesicles, prostate gland and Cowper's glands are sometimes referred to as the sex glands. This can be confusing because some people use this term for the testes. It is better to use the specific name for each gland.

Penis

The penis is the male sexual organ that delivers sperm to the female's vagina during sexual intercourse. At mating the semen passes out through the urethra, the same tube that takes urine out of the body.

The bull's penis delivers sperm as close to the cervix as possible during normal mating. The bull's penis is always quite firm but is held inside the sheath by a muscle that retracts it. The retractor muscle relaxes to allow the penis to extend for mating, then contracts again to retract the penis into the sheath for protection from injury and disease. During sexual arousal the penis also has greater blood supply and becomes fully erect for service.

Semen

This is the name given to all of the material discharged when the bull ejaculates – i.e., the sperm (for fertilising the egg) and the liquid secretions from the seminal vesicles, prostate and Cowper's glands, which nourish and protect the sperm. Most bulls ejaculate about 3 to 5 ml of semen containing about 1 billion sperm per ml – i.e., a total of 3 to 5 billion sperm.

Sperm (spermatozoa)

Sperm is the mature mobile reproductive cell of the bull, produced by the testes. It consists of a head section and a tail section. The sperm head is made up of the nucleus, which consists almost entirely of DNA, and a cap-like structure called the acrosome which enables the sperm to penetrate the ovum at fertilisation. The sperm tail functions by lashing from side to side to drive the sperm forward. Although sperm may be seen to be mobile under a microscope this does not automatically mean they are able to fertilise an egg.

When the bull is not sexually active (e.g., has no animals to mate with) the aging sperm in the epididymis die and are absorbed.

The Bull's Reproductive Hormones

Reproductive development and activity is controlled by natural chemicals (hormones) produced by the animal's body and circulated in the blood. The bull's basic reproductive hormones are quite simple.

Sperm and testosterone production in the testes is regulated by gonadotrophin hormones made in the anterior pituitary gland (a small gland attached to the base of the brain). If there is not enough of these hormones the bull can't become sexual mature. Gonadotrophin levels rise coming up to puberty, causing the bull's testes to grow and start producing sperm and testosterone.

The hormone testosterone is responsible for typical bull characteristics, such as:

- Development of the sex organs (including the testes, epididymis, and glands that provide fluids for semen)
- Sperm production
- Sex drive (**libido**) – the bull is normally interested in mating at any time if a cow in heat is available to him (contrast this with the cow's cyclical mating behaviour described later)
- Aggression – including behaviours such as digging holes, head rubbing or pushing against objects such as gates or posts, snorting, bellowing or mumbling at other bulls, fighting and territorial behaviour
- Greater appetite and growth (compared to females or castrated males)
- Larger mature body size and heavier bone growth
- Heavy muscling, especially the solid shoulders and neck crest
- Lower fat levels

Figure 2 A well grown 2½ year old Angus bull showing typical aggressive behaviour and bull shape

Development of the Bull's Reproductive System

Formation and Development

The testes are already developed when the bull calf is born and are usually found in the scrotum but are small and inactive at this stage. Occasionally they may still be tucked inside the abdomen – this is described as being 'undescended'. If both testes fail to descend after birth then the male is a **cryptorchid** and will be infertile because his testes are too warm. The cryptorchid will still have normal testosterone levels, so he looks and behaves like a bull. A bull with one descended testis will have normal sperm production in this testis and will be fertile.

As the bull grows, levels of gonadotrophins (from the pituitary gland) rise and cause the reproductive organs to grow and develop. The penis develops fully, the testes grow larger and the scrotum starts to hang lower as the bull reaches puberty. If gonadotrophin levels don't rise, the bull doesn't develop and reach sexual maturity.

Puberty

Puberty is the time when the young animal becomes capable of reproducing – i.e., the young bull produces a suitable volume of viable sperm at each ejaculation. It is related to age, body weight and weight of the testes. Age and body weight at puberty vary across breeds but scrotal circumference at puberty is consistently around 28–29 cm. Typical age at puberty is about 9 months but some early maturing breeds reach puberty much younger (e.g., 6 months) if well grown. Size is generally more important than age in determining the onset of puberty.

Sexual Maturity

Bulls generally reach full sexual maturity (i.e., full testes size and mating capacity) at 2 to 3 years of age. Their reproductive life in the herd depends on continued good health and the farm's management system. Many beef bulls on dairy farms are used for a single season and then killed for bull beef, so they never reach sexual maturity. On beef farms bulls are often used for many years so long as they remain sound.

Modifying Reproductive Development

Sometimes farmers choose to modify the bull's development – e.g., by castrating or vasectomising – for management reasons. Obviously bulls must be entire for mating and some farmers run bulls for beef production but many others prefer castrated steers because they are easier to manage and have a different beef market. The vasectomy is a specialised operation used in mating management.

Note that operations such as castration are governed by legal requirements in the Animal Welfare (Painful Husbandry Procedures) Code of Welfare 2018. It is an offence to breach the minimum standards set out in the code, and the recommendations for best practice are preferred.

For details on what is permitted under the Animal Welfare Act and how this can be carried out, check out the minimum standards from the Code of Welfare Painful Husbandry Procedures at
https://www.mpi.govt.nz/dmsdocument/1443/direct

Minimum Standard No. 3 – Castration and Shortening of the Scrotum (cryptorchid)

(a) The method of castration, or shortening of the scrotum, must be chosen, and applied, so as to minimise the acute as well as chronic consequences for the health and welfare of the animal.
(b) While complying with Minimum Standard 2(a), castration, or shortening of the scrotum, without pain relief must be performed when the animals are as young as possible, but not greater than six months of age.
(c) When castrating or shortening the scrotum of any animal over the age of six months, pain relief must be used.
(ca) Horses and pigs, regardless of age:
  i) must not be castrated without pain relief, and
  ii) may be castrated only by a veterinarian, or by a veterinary student under the direct supervision of a veterinarian throughout the procedure.
(cb) A cattle beast or a sheep that is over six months of age must not be castrated unless throughout the procedure the animal is under the influence of an appropriately placed and effective local anaesthetic that is authorised by a veterinarian.
(d) When using rubber rings to castrate, they must be placed above the testes and below the teats, and must be of a tension and size appropriate to the animal in order to ensure that blood supply to the testes and scrotum is stopped immediately.
(e) When shortening the scrotum with rubber rings, they must be placed below the testes taking care not to include the testes within the ring, and they must be of a tension and size appropriate to the animal in order to ensure that blood supply to the scrotum is stopped immediately.
(f) If high tension bands are used to castrate an animal:
  i) an appropriately placed and effective local anaesthetic that is authorised by a veterinarian for the purpose of the procedure must be used to provide pain relief (regardless of the age of the animal), and
  ii) the band must be positioned on the scrotal neck as close to the testes and as far from the abdomen as possible.

Castration

Castration is the removal of both testes, turning the bull into an infertile steer. It is commonly done at young ages to minimise stress on the animal and avoid problems arising from unwanted mating activity. Note that pain relief (e.g., local anaesthetic) **must** be used when castrating any animal over the age of 6 months.

Castration removes the source of both sperm and testosterone so steers lose their fertility and secondary sex characteristics. Compared to the same animals if they were left entire, they have lower appetites, slower growth, smaller mature size (but some steers can reach very large sizes), and less muscle and more fat when mature. Although they have low sex drive, steers may still be seen mounting and riding on-heat cows or heifers. However, they cannot be relied on to mark cows in oestrus like a vasectomised bull and will not encourage cows to start cycling.

Why are animals castrated rather than left entire? The most common reasons are:

- Beef from finished steers is often exported to higher value markets – bull beef is almost all used in manufacturing (i.e., processed, often for hamburgers and the United States market). Price premiums vary; sometimes prime beef from steers is worth more per kg than bull beef and sometimes this is reversed.
- Steers may be more suitable for the local trade beef market (i.e., butchers) because NZ customers usually prefer beef with more fat.
- Steers are easier and safer to handle, don't dig holes and do less damage to fences and other structures.
- Steers are much less prone to injury (e.g., from fighting or riding).

There is no risk of accidental pregnancies.

There are several common ways to castrate calves:

- Normal rubber rings (as used to dock lambs) can be used on young calves. One or two rings (as shown in Figure 3) are placed over the two testes and scrotum using the usual elastrator tool, putting the ring above the testes but below the bull calf's teat buds. The tight ring cuts off blood supply to the testes and scrotum. The tissues die, shrivel and fall off. Calves should be done as young as possible, ideally when less than 7 days old (though not within the first 12 hours of life). This is because in older calves there is a risk of the rings being too weak to completely cut off the blood flow, allowing arterial blood into the scrotum but not letting lower pressure blood back out in the veins. This may lead to infection and gangrene, which

Figure 3 Castrating a calf using two normal rubber 'elastrator' rings

Cryptorchid

Sheep farmers sometimes use a rubber ring to shorten the scrotum of male lambs to make them infertile while still retaining secondary sexual characteristics for rapid growth and lean meat production. They may take one testis off with the scrotum or leave both testes held against the abdomen (not pushed inside it) with the short scrotum. Body heat destroys sperm and makes most, but not all, of these lambs infertile. Technically they are not true cryptorchids but 'short scrotum' males.

In theory this could be done in cattle but it is not practiced. The risk of some bulls remaining fertile means they would have to be managed as entire bulls anyway.

Vasectomy

Vasectomy is a surgical operation where a portion of the vas deferens is removed so that sperm can't be ejaculated during intercourse. A vasectomised bull has functioning testes but as sperm cannot get out he is infertile. He produces normal testosterone levels and has secondary sexual characteristics such as aggression, territorial behaviour and sex drive. Only a vet can vasectomise a bull.

Vasectomised bulls are used as teaser bulls to:

- Encourage cows to come into heat – the presence of a sexually active bull can cause cows to start cycling
- Detect cows in silent heat (cows which cycle and ovulate but don't show behavioural signs) – the bull can smell cows in silent heat and will mount them as normal
- Assist with oestrus detection – e.g., when fitted with a chin ball harness that marks cows he has ridden, or by positive rubbing of tail paint or other heat detection aids

Test Yourself #1

1. Connect the male reproductive structure in list A with its function in list B.

A	B
scrotum	where sperm are stored and mature
testes	deposits semen at mating
epididymis	controls temperature of the testes
vas deferens	tube for semen and urine
seminal vesicles	produce sperm and testosterone
urethra	transports sperm from testes to urethra
penis	produces nutritive fluid in semen

2. List at least four secondary sex characteristics caused by testosterone.

3. Briefly explain the following words:
   a) Castration
   b) Vasectomy

4. Why are some male livestock vasectomised?

Reproduction in the Female

Female livestock reproductive health and performance are vital for farm production and profit on farms. Most mating management aims to get females to cycle on time and fall pregnant. Reproductive performance is affected by a wide range of issues including nutrition and many animal health problems. This section describes:

- The structure and function of the female reproductive organs and hormones
- The femlae reproductive cycle
- Formation and development of the cow's reproductive system
- Normal sexual behaviour
- Abnormal sexual behaviour
- Deformities, abnormalities and animal health problems that can reduce reproductive performance

Structure and Function of Reproductive Organs

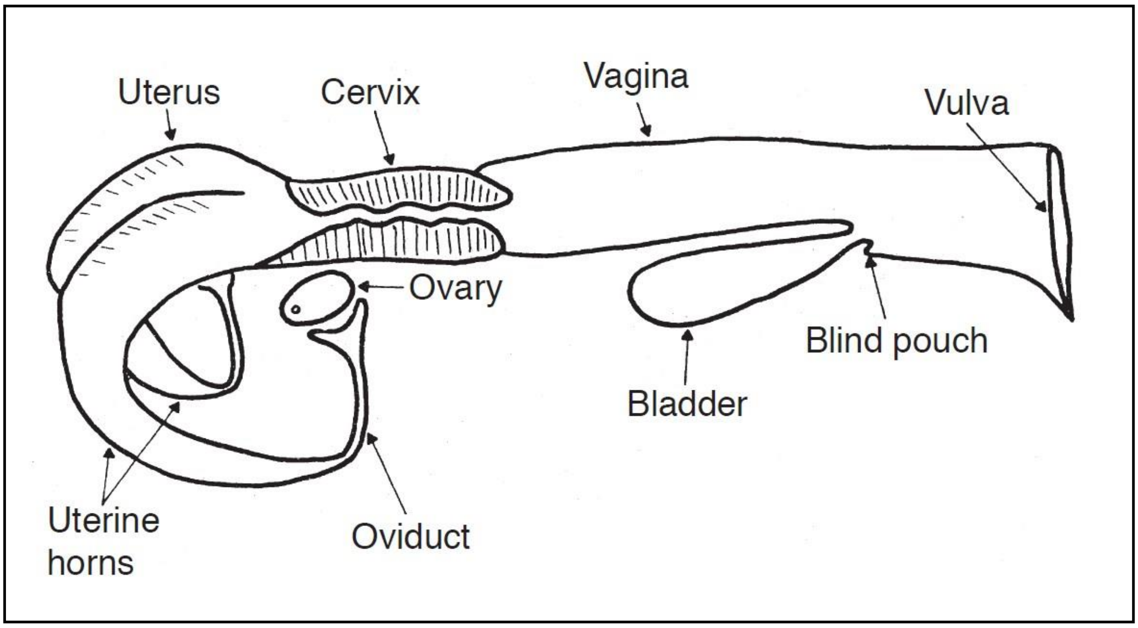


Figure 4 Reproductive tract of the cow

Source: from Turner, J (2014)

Ovaries

The cow has two ovaries and these have two important functions:

- Production of eggs (technically called **ova**)
- Production of female hormones **oestrogen** and **progesterone**

The ovaries and other reproductive organs are formed but immature when the heifer is born. Each ovary contains several thousand tiny structures called follicles. After the heifer reaches puberty one follicle will ripen or mature approximately every 21 days so long as she isn't pregnant. This repeating pattern is her 'oestrous cycle' and she is only receptive to mating for a short time each cycle (more about this later).

Each immature follicle consists of a germ cell (which could become an ovum) surrounded by a single layer of epithelial cells. As a follicle ripens, more layers of cells form around this and a large central cavity opens up. As the follicle and cavity grow, the egg is attached by a stalk of cells to the back of the follicle and the follicle bulges as the egg develops. This follicle becomes mature and is called a **Graafian follicle**. It produces large amounts of the female hormone **oestrogen,** important for making the cow show **oestrus**.

Unlike a bull, the heifer or cow is only interested in mating for a short time, when she shows oestrus. At this time she will accept the bull for mating but any other time she will resist and move away if any animal tries to mount her. In oestrus she shows sexual behaviours such as bellowing, sniffing other cows and riding other cows. Most importantly, she will stand to be ridden. (More details about oestrus in the section explaining the cow's reproductive cycle.)

The mature follicle ruptures and releases the egg at **ovulation**, which usually occurs after oestrus. The released egg travels down the **oviduct** (also called the fallopian tube) where it can be fertilised to become an embryo if the cow is mated at the right time. The egg remains viable for fertilisation for only a few hours.

After ovulation the ruptured follicle develops into the **corpus luteum** (CL), which produces another female hormone, **progesterone**. Progesterone prepares the uterus lining to receive the fertilised egg (or **embryo**). If an embryo embeds in the uterus then the CL continues producing progesterone to maintain the pregnancy until birth. If no embryo arrives (e.g., if the cow was not mated or failed to conceive) then the uterus produces prostaglandin, which destroys the CL, and she has another cycle.

Oviducts (or fallopian tubes)

These tubes carry the egg from the ovary to the uterus. The end nearest the ovary, where the released egg enters the oviduct, is called the infundibulum. Sperm that were deposited in the vagina (natural service), cervix or uterus (artificial insemination) pass up the oviducts to reach the egg.

The fertilised ovum passes down the oviduct over 3 to 4 days, helped by the movement of cilia which resemble microscopic fingers projecting from the cells lining the tubes. The waving motion of the cilia moves the ovum toward the uterus.

Uterus (or womb)

This is where the embryo develops and grows to become a **foetus** and finally a fully formed calf at birth. The fertilised ovum lodges in the lining of the uterus wall and the **placenta** (or afterbirth) develops to supply nutrients for the foetus. There is no direct blood connection between the cow and her calf: oxygen and nutrients diffuse from the cow's blood across the membranes of the placenta and into the foetus' blood supply. Carbon dioxide and other waste products in the foetus' blood diffuse back to the cow in the same manner.

Cervix

The cervix is also described as the neck of the uterus. It is about 100 mm long, with thick walls and a small opening that is filled with lots of mucus. The mucus and complex interlocking folds of the opening both help protect against infection. During oestrus the mucus becomes thinner and the cervix relaxes to allow easier passage of sperm after mating. After oestrus the mucus thickens again until the next heat.

In pregnancy the cervical mucus thickens to form a ‘plug’ that seals the canal and protects the developing foetus. You may see this plug pass from the vulva at the beginning of the labour. At birth the cervix expands to let the calf through and shrinks back to normal size after a few days.

Vagina

The cow’s vagina is a tube-shaped organ about 200 to 250 mm long which receives the penis and semen. Semen is usually delivered at the end of the vagina near the cervix in natural mating but may be put into or through the cervix in artificial insemination (AI). The vagina is self-cleaning due to mucus secreted from the vaginal wall. At birth the vagina provides a passage for the calf to pass out; care should be taken to do as little damage as possible during difficult calvings.

Vulva

The vulva is the external opening of the cow’s genital tract. Soft tissue (called the labia) at the opening protects the vagina and allows urine to exit (the bladder opening is just inside the vulva). At oestrus the vulva becomes congested with blood – you might notice that it looks fuller and pinker than normal. At calving the vulva becomes very soft and floppy, and this is one of the best signs that calving will happen within the next few days.

The Basic Oestrous Cycle

The cow’s reproductive cycle is the key to successful cattle mating on any farm. It is important to understand the stages involved, what happens and how they are controlled (e.g., by hormones). When we know what we can expect to see it is easier to notice when things are going wrong, so that cows can be treated or management adjusted.

The overall oestrous cycle is the period from the beginning of one heat to the beginning of the next. Cattle don’t have a breeding season like some animals (e.g., most sheep) and will cycle throughout the year if they are not pregnant.

Cows usually release one egg at each ovulation but sometimes they release two (or more) and many farmers have seen cows with twins. The average cow’s cycle takes 21 days but anything from about 18 to 24 days can be normal for individual cows. **Standing oestrus**, when the cow will stand for mating (also called being **in heat**), typically lasts 15–18 hours (range 2 to 30 hours) and **ovulation** happens about 12 to 14 hours after the end of standing oestrus.

Table 1 summarises the cow's hormones, body changes and behaviour over the 21 day cycle, assuming she does NOT become pregnant. The day she begins to show oestrus is day 0.

Table 1 Stages of the cow's oestrous cycle (assuming she does not conceive)

Day	***Major hormones***	***Physiological changes***	***Behaviour***
0	Oestrogen (and rising levels of luteinising hormone (LH) after the end of heat)	Body temperature is raised; cow may hold her milk. Mucus at cervix is thin, cervix slightly open, vulva swollen and redder than normal. As oestrus ends levels of LH rise to make the ripe follicle rupture (ovulation), about 12–14 hours after standing heat.	Standing heat = stands to be ridden (key sign). May be restless, bellow, stand with tail up, sniff and/or ride other cows. Oestrus behaviour is driven by the high level of oestrogen.
1–2	LH	Follicle changes into corpus luteum (CL).	Cow comes off oestrus and returns to normal behaviour.
2–5		CL grows rapidly and other follicles die away.	Normal non-sexual behaviour.
5–16	Progesterone	CL keeps growing (maximum size about day 12), producing progesterone. Progesterone suppresses all other follicles.	Normal non-sexual behaviour.
16–18	Prostaglandin	If no fertilised embryo arrives, the uterus begins producing prostaglandin, which kills off the CL.	Normal non-sexual behaviour.
18–19	Follicle stimulating hormone (FSH) and rising oestrogen levels	Follicles are no longer suppressed by progesterone so several begin waves of growth; oestrogen levels rise as one follicle dominates and becomes the Graafian follicle.	Normal non-sexual behaviour.
19–20	Oestrogen	Graafian follicle is very dominant and releases lots of oestrogen.	Cow starts to show pre-oestrus behaviour – sniffing, might ride other cows but will NOT stand to be ridden herself.

Hormones Throughout the Oestrous Cycle

The most important hormones for reproductive management are oestrogen, progesterone and prostaglandin because these are most likely to be manipulated to make cows perform the way we want. Things to remember about these:

- **Oestrogen** is produced by the ripening follicle and causes the cow to show oestrus. It also helps thicken the uterus lining (ready for an embryo) and causes the uterus to have rhythmic contractions that help sperm reach the oviduct after mating. Oestrogen is also responsible for secondary sex characteristics of the cow, such as slower growth and greater body fat compared to a bull. We can think of oestrogen as the main heat (oestrus) hormone and the 'action' hormone that makes things happen.

- **Progesterone** is made by the **corpus luteum (CL)** that forms from the ruptured follicle after ovulation. As long as the CL persists, the cow will not show oestrus or ovulate again because progesterone suppresses follicle development and oestrus behaviour. If the cow is pregnant then the CL persists and progesterone output continues. Progesterone prepares the uterus to receive the embryo, maintains pregnancy and stops uterine contractions. We can think of progesterone as the main pregnancy hormone and the 'quietening' hormone that calms activity down (after the 'action' promoted by oestrogen).
- **Prostaglandin** kills off the CL, stopping progesterone production and enabling the cow to have another cycle. This usually happens naturally if the cow doesn't get pregnant, but prostaglandin can also be given artificially to make the cow cycle again (used to synchronise cows' cycles and make them show oestrus together).

Figure 5 shows the changes in the levels of major hormones throughout the cow's oestrous cycle. Note that this figure includes other hormones (FSH and LH) that were mentioned in Table 4.

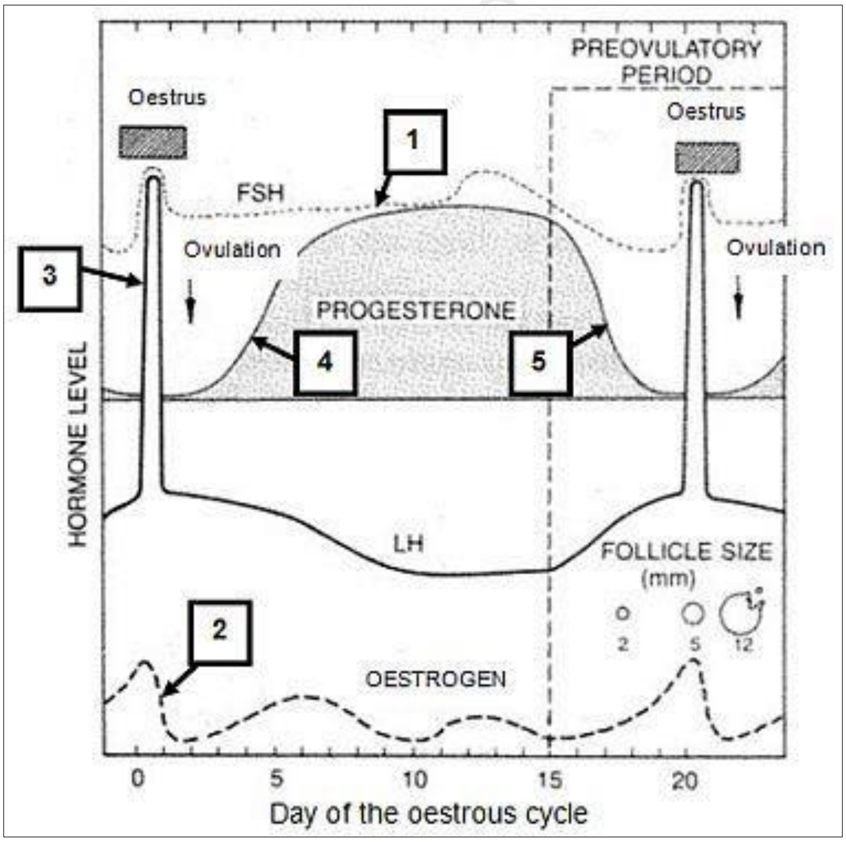


Figure 5 Hormone levels throughout the cow's oestrous cycle

Things to note from the diagram (the numbers match the numbers in the boxes shown in Figure 6):

1. Follicle stimulating hormone (FSH) from the pituitary gland starts the process by encouraging the follicles on the ovary to develop. FSH drops before oestrus in response to rising oestrogen levels from the maturing Graafian follicle.
2. Oestrogen rises and falls with waves of follicle development throughout the cycle but peaks to cause oestrus behaviour. (Rising oestrogen also makes FSH levels fall as oestrus approaches, because the cow doesn't need any more follicles to develop once the Graafian follicle takes over.) Oestrogen also makes the uterus have waves of contractions to help sperm reach the oviduct after mating.
3. When the Graafian follicle is mature the LH level spikes, causing the follicle to rupture for ovulation. (Cows ovulate spontaneously – i.e., they don't have to be mated first.)
4. Progesterone rises after ovulation, once the corpus luteum has formed and started producing it.
5. When the uterus starts producing prostaglandin (because the cow is not pregnant), the CL starts to die and progesterone levels fall again.

The Cow's Annual Breeding Cycle

The goal of cow management is the birth of a healthy calf every 12 months. The dairy cow needs to calve to come into milk so farmers want as many cows pregnant as possible, preferably over a short period so that calving is condensed and cows milk for the maximum time each year. Most dairy farms keep some heifer calves as replacements. The beef breeding farm wants as many cows pregnant as possible to generate replacements and surplus animals for beef production. Condensed calving helps to match the rise in feed demand for lactating cows with spring pasture growth, so that the calves are well grown by weaning.

Non-pregnant cows cycle about every 21 days and may or may not be mated. For example, well grown heifers may have several cycles before their first mating. Let's assume we have a mob of females that we want to get pregnant, either by natural mating or artificial insemination.

We will follow a cow from one calving to the next to study the stages of the reproductive cycle. The diagram (next page) shows how the 21 day oestrous cycle fits into a cow's annual reproductive cycle.

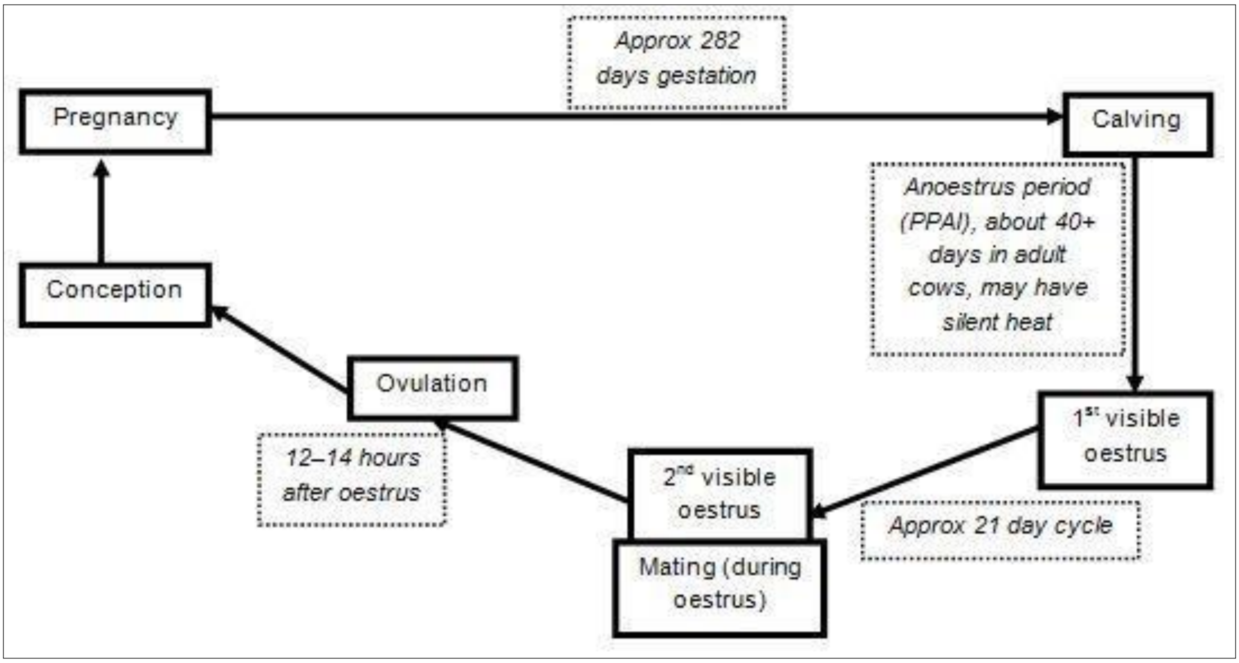


Figure 6 Typical annual calving cycle for a cow

Anoestrus

When a cow is not cycling (i.e., showing oestrus regularly), she is said to be **anoestrus**. It is normal for a cow to have a period of anoestrus after calving; this is called the **post-partum anoestrus interval** (**PPAI**). It is important that she starts showing oestrus in time for mating. During anoestrus the cow may have waves of follicle development but no follicles reaching maturity. The PPAI is usually defined as the time from calving until the cow's first obvious heat (note that most cows have at least one 'silent' heat first).

The average PPAI is about 40 days in mature dairy cows (DairyNZ Farmfact 2–1) and longer in young cows (2 and 3 year olds). The PPAI may be increased by poor body condition, underfeeding, or health problems – e.g., difficult calving, retained membranes or metabolic problems. Long PPAI is a major problem for many New Zealand dairy herds, leading to a long mating period and in the past the use of inductions to shorten calving (as of 1 June 2015, routine inductions are no longer allowed). A cow with a long PPAI may not cycle until AI is finished and will calve late or may miss mating altogether (in dairy or beef herds).

If a cow is to calve every 365 days then she has 83 days to get back in calf (allowing for 282 days gestation). If she takes longer than this then she will calve later next year than she did this year. We can see why PPAI is so important! If the cow conceives at her second standing oestrus, as shown in Figure 3, then she needs a PPAI of 62 days or less to calve at within 365 days. If she takes three cycles to conceive, her PPAI cannot be longer than 41 days. Cows with oestrous cycles longer than 21 days also need a shorter PPAI.

Oestrous cycles

After the PPAI the cow begins to show oestrus as normal, seen as standing heat every 21 days or so (as described in detail earlier). Cows can be mated to their first oestrus if necessary but the chance of conception is higher at the second and later cycles.

Mating

Ovulation usually occurs about 12–14 hours after the end of standing oestrus. The best chance of conception occurs when sperm meet the egg during the cow's most fertile period so the best time for insemination is from about 6 to 24 hours after the *beginning* of standing oestrus (DairyNZ Farmfact 2–6). Natural mating occurs in standing oestrus, when the cow is receptive to the bull.

In natural mating semen is ejaculated at the front of the vagina, releasing billions of sperm close to the cervix. Sperm pass through the cervix into the uterus and then into the oviducts. Good quality semen remains viable in the cow for about 28 hours so healthy sperm should be present in the oviducts when the cow ovulates. The egg has a much shorter life, about 6 hours after ovulation, which is why mating happens before ovulation (to give sperm time to get well up the oviducts).

Under natural mating, the cow may be mated several times, perhaps by more than one bull. This further increases the chances of fresh sperm meeting the egg at the right time.

Many dairy cows and some beef cows (especially in studs) are mated by artificial insemination. Semen is deposited by a technician, using a pipette to reach through the vagina and place the tip of the pipette in the cervix or into the uterus. The technician uses their other hand, placed inside the animal via the rectum, to feel the pipette placement. When it is correctly placed the semen is released and the pipette is withdrawn.

Figure 7 shows the most common insemination technique for cows. A right-handed technician puts their left arm through the rectum into the large intestine to find the cervix. The right hand introduces the pipette into the vagina and releases the sperm when the pipette tip is in the right place (the uterine body is the preferred target for sperm deposition in AI).

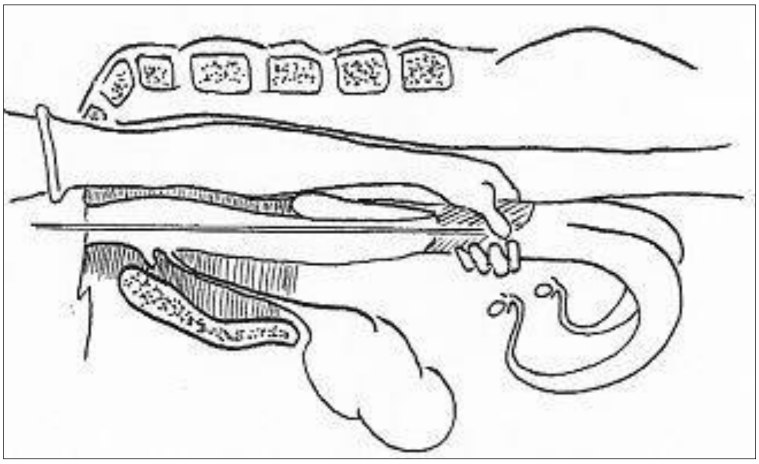


Figure 7 Typical AI technique for inseminating a cow

AI only works if sperm can meet a recently released egg – i.e., if the female is in oestrus and ovulates a healthy egg. Timing is important because cows are only mated when the technician comes (usually at the same time each day). This is one reason why conception rates to AI tend to be lower than for natural mating. Cows seen on heat should be mated at the next opportunity. This also applies to cows which have already been mated but appear to be still on heat.

Conception and pregnancy

The released egg is swept into the infundibulum and begins to travel down the oviduct. Conception occurs when a sperm pierces the egg. The sperm's tail is discarded and the nuclei of the sperm and egg unite so that the fertilised egg (i.e., the new embryo) has matching pairs of chromosomes.

Approximately 17% of all eggs that mature are abnormal and cannot be fertilised. After mating an average of 30% of all eggs are either not fertilised or fail to develop into embryos. This can be caused by oviduct blockages, fertilisation occurring too far down the oviduct towards the uterus, liveweight loss around mating, or failure of the embryo to implant.

Twins occur about once in every 50 to 60 cattle births (varying with breed), usually resulting from the separate fertilisation of two different eggs. Occasionally an embryo splits at an early stage to form identical twins. Twins have higher embryo loss, are smaller at birth and have lower survival.

The embryo grows by cell division as it descends the oviduct to the uterus over 3 to 4 days. In normal events, the mass of cells reaches the horn of the uterus and attaches to the uterus lining. The placenta develops and the embryo grows to become a foetus.

Initially the embryo is nourished by the stored yolk of the egg and then it begins to receive nutrients from the uterine lining. When the placenta (afterbirth) has formed, nutrients pass from the cow and waste from the embryo to the cow by means of blood vessels in the cotyledons (afterbirth buttons). The placenta has many cotyledons (typically 70 to 130 of them). The cow and embryo blood supplies do not mix; nutrients, oxygen and waste products diffuse back and forth across the placental membranes to feed the calf and remove its waste. The placenta also secretes hormones that help maintain the pregnancy.

Meanwhile the follicle that released the egg has become the corpus luteum and started to produce progesterone. At about day 15 of pregnancy a chemical signal from the embryo tells the cow's body that she is pregnant. The CL persists, grows quickly and continues to enlarge until about the middle of gestation. Progesterone from the CL has several functions:

- It prevents the development of further follicles, preventing further oestrus and ovulation.
- It helps sensitise the uterus wall, ready for implantation, and quietens uterine contractions.
- It is important for maintaining the required uterine environment during pregnancy.
- Oestrogen and progesterone both stimulate udder development.

Calving

Calving occurs after gestation (i.e., pregnancy period) of about 282 days. It is triggered by hormones including oxytocin and prostaglandin, which cause uterine contractions in response to hormone signals from the foetus. (Oxytocin also stimulates milk letdown – e.g., when the calf noses around the teats and tries to feed.)

Most cows calve naturally without assistance but some have trouble (dystocia), which may reduce future reproductive performance by increasing the PPAI and/or reducing conception. (Other units deal with the calving process and assisting with birth.) After calving the cow has a period of anoestrus and her annual reproductive cycle repeats.

Reproduction cycles and activity

Cow Behaviour

Cows are receptive for mating for a short period every 21 days so behaviour indicating oestrus is important, especially when cows are drafted for AI rather than being detected and mated by a bull. Farm staff must recognise signs of oestrus and behaviours that may indicate something wrong.

Normal Cow Behaviour

Most of the cow's oestrous cycle occurs without any outward signs. We usually notice her sexual behaviour when she is coming into heat and (especially) when she is in standing oestrus, but the changes are gradual.

Cows coming into oestrus

The cow coming into oestrus starts to take more interest in sexual activity in the 6–10 hours before she reaches standing heat. Things you might see:

- Seeking out other cows who are approaching oestrus or in oestrus in 'sexually active groups'
- Sniffing other cows
- May attempt to ride other cows but will NOT let other cows ride her
- Less grazing, more time walking or mixing with sexually active groups
- Restless and may bellow
- Physical signs such as moist, red and slightly swollen vulva

Cows in oestrus

The cow in oestrus is ready for mating. Standing oestrus averages about 15 hours but varies considerably (from 2 to 30 hours duration). Things you might see:

- 'Standing oestrus' – i.e., the cow stands to be ridden (by the bull or other cows)
- Rubbed hair and skin at the crest of the tail
- Rub marks or mud on her flanks (from the feet of riding animals)
- May stand with tail up and back arched
- Sniffing and riding other cows
- Less grazing, more walking and mixing with sexually active groups (extra walking and activity can be detected if she has a pedometer or activity meter)

- Nervous, excitable, restless and may bellow
- May hold milk
- Milk output may fall due to reduced grazing (detected in automated sheds that monitor each cow's production)
- Change in order while walking to cowshed or entering the shed (e.g., leading the herd or lagging behind)
- Physical signs such as moist, red vulva with a clear mucus discharge
- May have raised body temperature

Cows after oestrus

As oestrus passes the cow loses interest in sexual activity and goes back to normal herd behaviour. Things you might see:

- May sniff other cows but gradually loses interest in sexually active cows
- No longer lets animals ride her
- Clear mucus discharge gradually ceases
- Returns to normal activity levels, grazing and milk output

Abnormal Behaviour

The activities shown in oestrus might seem strange to people who don't know what is happening but they are all normal behaviours for cows in that part of their cycle. Occasionally cows show abnormal behaviours, such as:

- **Silent heats** happen when a cow shows no oestrus behaviour but ovulates. Cows often have a silent heat when they start cycling after calving but show normal oestrus behaviour at their following cycles. Bulls detect cows in silent heat (by smell) but these cows are missed when people draft cows for AI, unless they have been marked by a teaser bull.
- **Continued anoestrus** after calving is not normal. Tail painting before mating is often used on dairy farms to check that cows are cycling normally before mating is due to start. Anoestrus cows can be checked by the vet and treated if necessary in time to cycle while AI is continuing. (Waiting until the first cycle of AI is complete would mean these cows would probably miss their chance at AI and instead go to the beef bull.)
- Some cows stop showing oestrus after one or more normal cycles but are not pregnant (sometimes called 'phantom cows'). Under normal conditions the non-pregnant uterus makes prostaglandin that kills off the CL from the last ovulation, allowing her to cycle again. If she does not cycle then the CL may not have died down and her progesterone level has stayed high (as it does in pregnancy). A prostaglandin injection may fix this, but will cause embryo loss if she is truly pregnant.
- Some cows have very short standing oestrus (e.g., 6 hours) which means the bull must find her in a short time – not always practical in extensive farming. It is hard to know when these cows ovulate so AI may not be at the right time for her.
- Short cycling means cows return to oestrus at short intervals (e.g., 7 to 11 days). The first heat after calving may be followed by a short cycle but later in the season short cycles may indicate cystic ovaries or problems with the corpus luteum (e.g., no CL forms after ovulation or the CL makes little progesterone). Get veterinary advice about these cows.

- Irregular cycles indicate something wrong with the cow's hormone levels (this has several possible causes). These cows may ovulate without showing oestrus or show oestrus but not ovulate, so conception tends to be low. Get veterinary advice.
- Some cows ride other cows often, either due to frequent oestrus or regardless of their own stage of the oestrous cycle. Some farmers call these nymphomaniac cows. High sexual activity is fine if she has normal heats but can indicate a hormone problem or cystic ovaries. She should be checked by the vet if she never shows standing oestrus, has standing heat at short intervals, or cycles repeatedly without getting pregnant.

Development of the Cow's Reproductive System

Formation and Development

The ovaries, oviducts, uterus, cervix, vagina and vulva are all formed and present when the heifer calf is born. The external genitals can be recognised and the calf urinates from just inside the lower edge of the vulva like an adult cow. The ovaries contain thousands of germ cells that can develop into eggs for ovulation when she is older, but only a tiny percentage ever reach maturity.

As the heifer grows she begins to produce more gonadotrophins (hormones that stimulate the gonads – e.g., FSH and LH) from the pituitary gland. These hormones make her reproductive organs develop further and begin to ripen immature follicles on her ovaries. Rising levels of FSH encourage follicles to develop and mature and these, in turn, produce oestrogen and cause LH to rise. Eventually a follicle becomes mature enough to cause a big surge in oestrogen, triggering the heifer's first oestrus.

Puberty

Puberty in heifers is the time when they show first oestrus and ovulate – i.e., they are mature enough to conceive a calf. It is influenced by age, breed and weight. Most heifers reach puberty at about 60 to 70% of mature liveweight (range 40 to 70%) so well grown heifers are younger at puberty. Heifers born early in the calving season are usually heavier (because they are slightly older) so they are most likely to be the ones that reach puberty in time for mating as yearlings.

Seasonality of Reproduction - Sheep

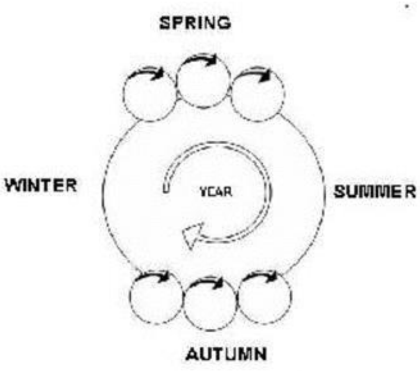
Sheep are seasonal breeders. In other words, they only breed at certain times of the year. Decreasing day length triggers ewe breeding activity, the oestrus cycle. In practice, this means in New Zealand ewes of most breeds cycle from around March until August, but some begin earlier (e.g., late summer, about
February). Rams' testes size, sperm production and libido (mating urge) also increase as day length shortens. In contrast to ewes however, rams are capable of breeding at other times because some sperm is always present.

The number of ewes cycling and their ovulation rates increase toward the middle of the breeding season, then decline as the season progresses. To maximise the potential lambing percentage, ideally mating should take place near the peak of cycling activity. Ewes usually release more eggs in their second and subsequent cycles than at their first oestrus of the season, so multiple births increase if ewes are not mated too early in the autumn. Ewe pregnancy length (gestation) ranges from 140 to 150 days, approximately five months.

The part of the year when ewes are not cycling is called anoestrus. In breeding ewes it typically lasts from lambing in spring until the next breeding season begins in autumn, about 4–5 months depending on when ewes start cycling.

The seasonal nature of ewe oestrous cycles

Decreasing day length stimulates the onset of oestrous cycles. Once a ewe is pregnant or as day length increases, oestrous cycles stop. A ewe may have only one cycle if she gets pregnant when mated at her first oestrus. If she is not successfully mated, she will continue to cycle until the rate of decreasing day length slows or increasing day length triggers anoestrus (shown as the dotted line below).



seasonal breeders

Image retrieved from https://en.wikibooks.org/wiki/Anatomy_and_Physiology_of_Animals/Reproductive_System.

Because most ewes mate in autumn they lamb in spring. This coincides with peak pasture quantity and quality. Spring grass is leafy, with little seed and stalk until late spring, and pasture growth rates are high. Adequate amounts of good quality pasture are important to meet high ewe energy demands during lactation (when she produces milk). Good quality pasture is also required once lambs begin to graze.

Seasonality of reproduction – Deer

The main species of deer that are farmed in New Zealand are.

Red deer	Cervus elaphus
Elk or wapiti	Cervus elaphus nelsoni
European fallow deer	Dama dama

Subspecies are more closely related and they can interbreed, producing fertile offspring. For example, in New Zealand, deer subspecies like wapiti and red deer can be mated and they produce fertile offspring, but breeding between reds or wapiti and fallow is impossible.

Deer are more strongly seasonal than other livestock species, and stags in particular show huge changes in appearance and behaviour as the seasons change. I n autumn (the mating season) they are very aggressive.

The breeding pattern for stags and hinds is associated with changing day length and this is also triggered by the decreasing day length of Autumn.

The mating season is associated with very distinctive stag behaviour. In summer, in preparation for rutting during autumn the stags put on a lot of weight much of it as fat and their velvet antler grows fast. They are relatively docile at this stage and the velvet antler is very sensitive. Then as autumn approaches, the velvet dries and hardens, their testes enlarge, their larynx enlarges and becomes obvious just below the throat area, they begin to roar and they become very aggressive. They are a real hazard to each other and to stockmen.

Associated with reproduction are the antlers, secondary sexual characteristics peculiar to deer. With the exception of the reindeer, *Rangifer tarandus*, and its north American relative, the caribou, *Rangifer arcticus* in which the females carry antlers, only males bear antlers.

Antlers are replaced annually, growing before the mating season and hardening in response to increasing levels of testosterone as the rut approaches. During the growing phase when testosterone secretion is low, the antlers are live, soft, sensitive, and vulnerable, but as the rut approaches testosterone secretion increases, causing them to harden by cutting off of blood vessels and mineralisation of the antlers.

Test Yourself #2

1. Connect the female reproductive structure in list A with its function in list B.

A	B
ovaries	where the sperm is deposited during natural mating
oviduct	produce eggs and hormones
uterus	external vaginal opening
cervix	where fertilisation occurs
vagina	where the embryo develops
vulva	protects developing calf from infection

2. Connect the female hormone in list A with the description in list B.

A	B
oestrogen	made by the non-pregnant uterus, kills the corpus luteum so that the cow can cycle again
progesterone	made by the pituitary gland, stimulates follicles on the ovary to develop
prostaglandin	made by the pituitary gland, makes the uterus contract and causes milk letdown
oxytocin	made by the corpus luteum after ovulation, prepares the uterus and maintains pregnancy, stops the cow from cycling again
follicle stimulating hormone	made in large amounts by the mature follicle, surges before ovulation, makes the cow show oestrus

3. True or false?
   a) Anoestrus is the period when the cow is ready for reproduction.
   b) Oestrus is when the cow is ready to mate.
   c) Eggs are produced inside individual follicles on the ovaries.
   d) Once the egg is fertilised the production of progesterone stops.
   e) Fertilisation occurs in the oviduct.
   f) The pregnancy length is also known as the gestation period.
   g) The foetus gets nutrients and oxygen via the placenta.
   h) Ovulation occurs during oestrus.
   i) Cows are seasonal breeders and only show oestrus in spring.
   j) Heifers always reach puberty at 9–11 months old.
   k) Puberty is affected by liveweight so well grown heifers reach puberty earlier than smaller ones of the same breed.
   l) Some cows show no signs of oestrus but ovulate anyway.

Physical Abnormalities and Reproductive Health Problems in the Cow

This section deals specifically with reproductive abnormalities and health problems that can stop a cow from cycling, kill her calf in pregnancy (i.e., abortion) or make her permanently infertile. Many aspects of general health and management affect the chances of cows getting in calf in any year – these are dealt with in later sections about general health, nutrition and management.

Physical Defects and Abnormalities

Physical defects can be temporary or permanent. Common problems are described here.

Blocked oviducts

Some cows show oestrus and ovulate normally but the egg is not fertilised because the sperm cannot pass through blocked oviducts. These cows will be culled for failing to get pregnant if both oviducts are blocked, while cows with one blocked oviduct may be late getting in calf.

Cystic follicles or cystic ovaries

Sometimes a follicle persists on the ovary as a large fluid-filled bubble (a cyst). The cow may return to heat at short intervals (less than 21 days), may appear to be on heat most of the time (sometimes referred to as nymphomaniac cows) or may not cycle at all.

Freemartins

Freemartins are heifers with abnormal reproductive organs caused by sharing a placenta with a male twin. About 70% of heifers born as twins with a bull calf are infertile. The heifer is genetically female but her organs (especially ovaries) are underdeveloped due to the bull calf's testosterone. She may have normal or deformed external genitals (e.g., vulva). Some heifer twins are fine if the two calves had separate placentas. Low value heifers are best sold as calves but it can be worth having the vet check high value animals (physically and by blood test) before culling.

Diseases

Diseases can interfere with any stage of the cow's reproductive cycle, from the anoestrus period after calving to the loss of her next calf in late pregnancy (i.e., abortion). We discuss major reproductive diseases here but others occasionally cause problems on individual farms.

Abortion

Abortion can be caused by disease (important ones are discussed below) or damage (e.g., being jammed in a gateway). The occasional abortion is common but outbreaks or 'abortion storms' must be investigated quickly. Seek veterinary advice if several cows abort in a short time.

Dystocia (difficult calving)

Damage and stress associated with difficult calving can increase PPAI and/or reduce the chance of successful embryo implantation (e.g., if the uterus is damaged). Cows having trouble calving must be helped as soon as a problem is recognised, assisted as gently as possible with plenty of lubricant (to minimise tissue damage) and if necessary treated with antibiotics to prevent infection. It is useful to keep a record of assisted cows so that they can be checked before mating.

Bovine viral diarrhoea (BVD)

BVD has different effects depending on the stage of pregnancy the cow is at when she is infected with the virus. Contact in early pregnancy causes embryo death, which is usually not associated with obvious clinical signs and only apparent as an increased number of non-pregnant cows. Contact later in pregnancy can cause abortion, birth defects, or calves that are persistently infected (PI) carriers, providing a pool of infection for other cattle.

Leptospirosis

Leptospirosis can cause cows to abort and is important as a zoonosis (a disease that can be passed to humans) that causes serious illness in people.

Neospora abortion

Neospora caninum protozoa (small parasitic organisms) are the most commonly diagnosed cause of abortion disease in dairy cows in New Zealand (Hittmann, 2007; Stewart, 2013

Retained foetal membranes (RFM)

Membranes and placenta that remain in the uterus after calving can cause infection (endometritis, commonly called metritis), increasing the PPAI and reducing the success of embryo implantation if the cow does cycle and conceive.

Vaginitis

Vaginitis means inflammation of the vagina and is caused by bacterial infection. The inflamed vagina may be so irritated that the cow strains and may discharge pus. In natural mating the infection can pass to the bull's penis, which becomes inflamed and too painful to serve cows.

Salmonella Brandenburg

Salmonella Brandenburg is a particular strain of *Salmonella* bacteria that can have serious effects on pregnant cows. The disease can be passed to humans (i.e., it is a zoonosis) and causes nasty illness. Cows can be vaccinated but vaccination is not 100% reliable.

Other abortion causes

Many viruses, fungi and bacteria, as well as chemicals and plants can cause abortion. Eating macrocarpa (*Cupressus macrocarpa*) foliage can cause abortion but is easy to prevent by avoiding paddocks with macrocarpa trees or hedges, or fencing them off. Less common abortion diseases in cattle include *Campylobacter* species bacteria, *Trichomonas foetus* and other pathogens.

Physical Abnormalities and Reproductive Health Problems in Sheep

For successful reproduction, ewe and ram reproductive organs need to be healthy and free from diseases and abnormalities. This section looks at common health issues and management practices to overcome them.

Ram reproductive health

There is a close relationship between testes size (reflected by scrotal circumference) and sperm production. Rams with small testes may not produce enough sperm before and during the mating period to maintain good fertilisation rates. Small scrotal circumference can have a number of causes, including immaturity, poor nutrition and developmental defects. Small testes in well grown young rams should be viewed with suspicion.

For acceptable performance the scrotal circumference should be greater than 28cm. This can be measured with a tape measure. Scrotal circumference increases with age and some rams in good condition may have circumferences of up to 40 cm. The scrotal circumference of Romney rams should be in the range of:

- November – mean measurement 32cm, range 29 to 35cm
- March – mean measurement 35cm, range 33 to 40cm.

Figure 8 Ram scrotums

These rams all appear to have good sized scrotums but they would need to be palpated to check their health status.

Image retrieved from http://pedigreesheep.com/sales.htm

Testes should be firm and springy with no abnormal lumps on palpation (examined by touch). Common faults detected by palpation include:

- small, undescended (tucked up in the abdominal cavity rather than in the scrotum), single testes
- abscesses
- atrophy (shrinking)
- epididymitis (inflammation of the tubes through which the semen is transported) which can be caused by *Brucella ovis* or other bacteria.

All of the above conditions can severely reduce sperm numbers and vitality.

The prepuce and penis (pizzle) should be checked for inflammation and damage. Causes should be identified and treatment given. Shearing wounds around the pizzle or scrotum can severely affect performance, especially if infection results. Deep abscesses may extend to deeper structures and cause permanent damage. Rams should be shorn at least 8 weeks prior to mating to allow time for any wounds to heal. It is important that rams are shorn, or at least crutched, as a woolly scrotum can also increase testicular temperature, reducing sperm viability.

Scrotal mange

Scrotal mange is caused by a mite (*Chorioptes bovis*) that thickens the scrotal skin. This raises the temperature of the testes which can significantly reduce the number and viability of sperm. Rams with significant scrotal mange may need to be replaced. Mild to moderate mange needs to be treated immediately with organophosphate dip or other suitable product. Seek veterinary advice.

Pizzle rot

Pizzle rot (also called balano-posthitis) is caused by bacterial growth in the sheath, associated with high protein pastures (common in NZ). The bacteria produce ammonia which has a scalding effect on the penis and prepuce. It starts as a small ulcer but can progress to scabs, pus and rotting material in the sheath. If the outlet becomes blocked then urine cannot escape, swelling the sheath and making the condition worse. Severe cases may not be able to extrude the penis but this is more common in wethers than rams.

Mild cases can be treated by switching to a restricted low protein diet, e.g., moving affected rams into a woolshed and feeding hay with unlimited water. Severe cases can be dosed with ammonium chloride under veterinary advice. Some animals may need to have the prepuce cut open to drain urine and pus; such rams should be culled because they may never recover full soundness for mating.

Brucellosis

Ovine brucellosis is caused by the bacterium *Brucella ovis*. Infection causes pus and lesions (thickening or lumps) in the epididymis, known as epididymitis. It may reduce fertility or, if both testicles are affected, cause total infertility because sperm count and sperm motility are poor. If palpation of the scrotum detects abnormal lumps or uneven testicle sizes then the ram should be blood tested to check for brucellosis.

Brucellosis is spread when infected rams 'ride' other rams. It can also be spread when rams mate with ewes that have been previously served by infected rams. On commercial farms total eradication of brucellosis is often difficult although should be the goal. If brucellosis is detected in any of the flock's rams then all should be blood tested. Culling of infected rams and purchase of rams from breeders with brucellosis-free accredited flocks can reduce the level of infection.

Brucellosis can also establish in the uterus of a pregnant ewe, however it is only carried for the term of that pregnancy. The bacteria can cause abortion, but more commonly results in the birth of small, weak lambs; both of these effects further reduce lambing percentage.

Foot rot and lameness

Any health condition that causes lameness can reduce mating performance because rams are less willing or able to graze (so they may lose condition, reducing sperm production) and cannot move freely around a mating mob to find ewes on heat. Mounting and mating may be painful or impossible, reducing the number of ewes served by the lame ram. This is especially serious if ewes are single sire mated or there are large numbers of ewes per ram.

Foot rot is a common cause of lameness in NZ flocks. Infection can raise testicle temperature (due to fever) and cause rams to lose condition because grazing is limited. Foot rot should be controlled in ewes and rams prior to mating. Common treatment measures include foot bathing, preferably with zinc sulphate (sometimes formalin), and culling animals that are repeatedly infected. Antibiotics may be recommended by the veterinarian. Vaccination is available for prevention but needs careful planning to coincide with times of maximum foot rot challenge. Selecting rams for foot rot resistance helps but is a long term measure.

Ewe reproductive health

There are a number of factors that can cause abortions, reduce ovulation rates or otherwise reduce successful pregnancy rates. These include:

- diseases – toxoplasmosis and campylobacter
- mineral deficiencies – selenium, iodine
- pasture toxins – facial eczema, zearalenone and endophytes
- pasture phyto-oestrogens

Most of these issues can be rectified through appropriate management, for example using vaccines, supplementation and careful grazing management to address local issues.

Diseases

Prior to mating ewes should be vaccinated with Campylovexin or CampyVax4, and Toxovax. These vaccines control the contagious diseases toxoplasmosis and campylobacter which are the most common causes of abortion in sheep. Younger ewes are most susceptible. Although these diseases don't affect ewe fertility at mating, if not prevented they can reduce the possibility of a successful pregnancy.

Toxoplasmosis is a parasite spread in cat faeces and ingested by ewes along with hay or pasture. Ewes can be infected at any stage of pregnancy, resulting in death of the developing lamb (foetus), or the death of newborn lambs. Infection early in pregnancy may be seen as 'dry' ewes at pregnancy scanning[1] because the foetus has already been lost. Reproduction is unaffected in ewes that were infected when not pregnant. Infected ewes are usually immune for life thereafter. One dose of Toxovax vaccine gives lifetime protection against toxoplasmosis. Lambs or hoggets should be vaccinated as early as practicable (after 12 weeks of age), as natural infection makes the vaccine ineffective. The latest date for vaccination is one month before teasers or entire rams are introduced to ewes.

Campylobacter infections can cause embryonic death, abortion or the death of the lamb soon after birth. Sheep are most commonly infected by *Campylobacter fetus fetus*, which typically causes abortion in the last six to eight weeks of pregnancy and weak lambs if carried to full term, but *Campylobacter jejuni* can also cause earlier embryonic death and abortion. The disease is spread by ewes grazing pasture infected by bacteria, e.g., spread from aborted material or from discharges from infected ewes. Campylobacter vaccines should be administered twice before mating, with a four week interval between vaccinations. A booster is needed before mating in later years. Failure to boost may leave ewes with limited protection.

Mineral deficiencies

Many New Zealand soils are deficient in **selenium,** resulting in selenium deficient pasture and animals. Selenium deficiency may cause low ewe fertility due to increased embryonic loss in the first 3 to 4 weeks of pregnancy, white muscle disease in lambs and poor growth in lambs. It can be corrected by using fertilisers containing selenium, added to drenches or long acting selenium injections. Selenium drenches or injections should be given two to three weeks prior to mating. Many farmers also supplement ewes with selenium in late pregnancy to ensure lambs have sufficient selenium to prevent white muscle disease. Farmers should seek veterinary advice to develop a suitable plan for their location and farming system.

Areas most at risk from **iodine** deficiency include inland areas (coastal rainfall is likely to supply significant iodine inputs) along with areas receiving high rainfall, such as Westland, however it may occur in other regions as well. Forage crops containing goitrogens, such as brassicas, may affect iodine status anywhere in New Zealand. Goitrogens reduce thyroid hormone production and utilisation, leading to an increase in the need for dietary iodine requirements.

Iodine deficiency can lower fertility of ewes, as well as reduce milk and wool production, but this can be highly variable. The major effects are seen later in pregnancy causing higher death rates of newly born lambs, as affected newborns have a reduced ability to regulate body temperature or suckle from the mother. Additionally, iodine has a vital role in the growth and development of the foetus in general and specific organs, such as heart, lungs and brain, in particular. In areas where iodine deficiency is present iodine injections, such as Flexidine, should be given to all ewes by at least 6 weeks pre-mating. Oral potassium iodide can also be given to ewes at scanning and before lambing (particularly if feeding on crops with goitrogens) to help prevent goitre and other iodine deficiency symptoms in lambs.

Pasture toxins

Facial eczema (FE) is caused by ingesting the fungus *Pithomyces chartarum*, the spores of which contain sporidesmin, a toxin that causes liver damage, sensitivity to sunlight and decreased reproductive performance. It can affect both rams and ewes. Lower fertility (i.e. number of ewes lambing/number of ewes mated) and fewer multiple births can result from exposure to FE.

Figure 9 Sheep with severe clinical facial eczema

Practices to reduce the effects of FE in warm, humid areas (mainly the North Island) where FE is prevalent include:

- spore counting to identify 'safe' paddocks
- growing alternative crops for use around mating
- lax grazing (i.e., moving the sheep before they must graze into the dead material at the base of the pasture) if ewes must graze pastures with high spore counts
- zinc dosing

Fungicide sprays can be used in some circumstances. Breeding for resistance to FE and use of FE tested rams can minimise the effects of FE long term.

Zearalenone is a toxin produced by a range of Fusarium fungi in pasture. Intake of zearalenone before mating affects oestrus behaviour (decreased cycle length, increased oestrus duration), and reduces ovulation and fertilisation rates. The number of barren ewe's increases and fewer ewes have multiples. As with FE, zearalenone occurrence is greatest in late summer/autumn but unlike FE, zearalenone levels don't follow the pattern of spore production so spore counts are not helpful. Pasture levels of zearalenone can be measured and sheep urine testing is the best indicator of ewe exposure to it. The only control measure is to avoid grazing infected pastures, or 'lax' grazing to discourage animals from grazing into the base of the sward where fungus lives. There is no treatment or vaccination to overcome zearalenone effects but they are temporary.

Endophyte is a fungus found in many grass species. It produces a number of compounds that are toxic to a range of insects and other grass pests enhancing the yield and persistence of the host grass. However, some types of endophyte can also cause animal health problems such as ryegrass staggers. Ryegrass staggers outbreaks often occur from late November until the end of April, but the problem is sporadic and tends to be worst from late January to early February. If it does occur during mating it can interfere with mating performance, and ram and ewe health. Animals get tremors, stagger and/or fall over or get over heated depending on the actual toxin involved. Animals need to be removed from the affected pasture or fed supplements so they ingest less of the pasture and the offending endophyte. A number of endophytes, commonly called 'novel' endophytes, are less toxic to stock and are now available in grass cultivars. As with zearalenone there is no treatment for affected animals but they recover spontaneously when grazed on non-endophyte pasture or other feeds such as clover or other non-grass species (e.g. chicory). Ryegrasses with 'safe' endophytes (which provide protection against insect pests but do not affect grazing livestock) are commercially available and can replace risky high endophyte pastures in the longer term. Non- endophyte grasses, such as cocksfoot or prairie grass, may also be suitable depending on farm location and management.

Legume phyto-oestrogens

Phyto-oestrogens can be present in legumes such as red clover, subterranean clover and Lucerne. These compounds mimic natural oestrogen and can cause a reduction in ovulation rates or other changes in reproductive organs. A few plants in a pasture are unlikely to have any adverse effects but pure swards can cause problems.

A phyto-oestrogen called coumesterol tends to rise in Lucerne if plants are damaged (e.g., by fungal diseases or insects). Effects of grazing Lucerne can vary widely. Flushing and mating ewes on Lucerne has been found to reduce lambing percentage by 10–40% due to lower ovulation rates. Barrenness (the number of ewes that do not get in lamb) only increased by about 2%. Effects are temporary and appear to be overcome by as little as 7–14 days on grass/clover pasture before mating.

Plants such as subterranean clover and some varieties of red clover contain different phyto-oestrogen compounds which appear to affect the cervix (and sperm passage) more than the ovaries and ovulation rate. Trials comparing ewes on higher oestrogen red clover for 6 months before mating with ewes grazed on ryegrass/white clover pastures showed only small effects on ovulation rate. Similar proportions of ewes were marked by the ram in the first cycle but 30% more of the red clover ewes returned to service, i.e., failed to get pregnant when mated. This was thought to be caused by changes in the mucus in the cervix, stopping sperm from getting through. High intakes of similar plants before puberty can cause permanent changes in the reproductive organs of ewe lambs, leaving them infertile for life. This damage is not reversible.

Physical Abnormalities and Reproductive Health Problems in Deer

Undernutrition and malnutrition

Undernutrition (too little feed) and malnutrition (an imbalance or deficiency of components of the feed) have the potential to adversely affect reproduction in deer. Unthrifty hinds may come into oestrus later in the season, give birth to small fawns and produce less milk than hinds in good body condition.

To maximise conception rates, the hinds must be in good body condition at the start of the rut. If there is insufficient pasture then supplementary feed must be provided.

To ensure good foetal growth, hinds must be given adequate nutrition throughout the winter, but a slight (up to 10%) loss of body weight during this period should not be considered abnormal. Supplementary winter feeding to maintain summer weights is wasted since the normal compensatory weight gain on summer pasture will not occur and nothing will be gained.

Nutrition in the last month of pregnancy must be carefully controlled to prevent hinds from becoming overweight and lazy. Overfeeding hinds in good body condition may cause birthing difficulties (dystocia). This is especially so where wapiti stags have been used over red deer hinds, since the fawns of such crosses will be larger than those the hind would normally bear. Supplementary feeding should be stopped or reduced, and where possible the hinds should be encouraged to exercise. This can be achieved by holding back supplementary feed just before the spring flush so that the animals have to disperse to find forage.

Livestock species vary in their susceptibility to copper deficiency, with deer and cattle generally more susceptible than sheep, and wapiti more susceptible than red deer. The minerals molybdenum (Mo), sulphur (S), iron (Fe) and zinc (Zn) can inhibit the absorption of copper and cause a copper deficiency even when soil levels of copper appear to be adequate. This type of copper deficiency is typically more common than a deficiency caused by low soil levels of copper as such. Care needs to be taken when adding molybdenum to fertiliser to ensure it does not create a copper deficiency, particularly if sulphur levels are also high.

Copper deficiency in deer may cause sub-clinical production losses such as slightly lower growth rates that could be attributed to other diseases or conditions. Clinical signs of copper deficiency in young deer are mainly reduced growth rates and adult deer develop a condition called ‘swayback' (enzootic ataxia) where they lose coordination of their hind end. Any reduction in growth rates may lead to delayed puberty in young hinds thus poorer conception rates. Hinds with enzootic ataxia are unlikely to be able to mate (they have difficulty standing) and will also reduce conception rates. Other symptoms may include coat changes, poor milk production, diarrhoea, weight loss and skeletal defects.

Iodine deficiency has been associated with goitre, stillbirths and the birth of weak fawns. Fawns that are deficient in iodine during gestation may have goitre (enlarged thyroid glands), gestation may be prolonged, and if fawns are born alive they will be sluggish and susceptible to hypothermia. This can occur on soils and pastures that are iodine deficient but it may also occur when dams have been fed brassicas because these contain a goitrogen (goitre-producing substance). Prevention is by long-acting iodine injection of hinds.

Selenium deficient soils are common in New Zealand, and selenium deficiency has been associated with various ill-thrift and muscle problems in young deer. However although selenium deficiency has been associated with infertility as well as ill-thrift and muscle problems in the US and UK, there are so far no reports of selenium deficiency causing reproduction problems in this country.

There are two broad categories of vitamins, fat-soluble (Vitamins A, D, E, and K) and water-soluble (including all the B vitamins, niacin, folic acid, and vitamin C). Fat-soluble vitamins can be stored in the deer's liver and fat, whereas water-soluble vitamins cannot be readily stored. However water-soluble vitamins can be synthesized by microbes in the rumen, whereas only one of the four fat-soluble vitamins (Vitamin K) can be produced by rumen microbes.

Vitamin D is synthesized in sufficient amounts when deer are exposed to sunlight so vitamin A and E are the main vitamin deficiencies that could possibly occur. Vitamin E and precursors of vitamin A are abundant in green, leafy forage; thus deficiencies are only likely during extended drought or perhaps winter. In general vitamin deficiencies are unlikely under New Zealand deer farming conditions but grain based supplements containing vitamins A and E could be fed to deer if required.

Infectious diseases

New Zealand deer farming industry is fortunate because this country is free of many of the significant infectious diseases that can have adverse effects on both production and trade.

Brucellosis in deer is generally caused by Brucella ovis and it is a cause of abortion, inflammation of the testicles [orchitis] and inflammation of the uterus or womb [metritis] in deer in the US.

Brucellosis is a cause of infertility in rams in New Zealand, and it has recently been shown that on a few farms it has spread from rams to stags and from stag to stag, probably by sniffing or lcking of infected semen. It caused infertility in the stags.

Leptospirosis does occur in farmed deer and this disease has the potential to cause obvious disease. However where it occurs it tends to be subclinical ie it causes lesions but these don't cause signs of ill-health. Depending on the type of leptospire involved, the main effect of leptospirosis is to cause liver disease with jaundice; or anaemia and redwater (red urine) as well as fever and sometimes abortion. Deer with acute infections and fever may sometimes be found dead with no warning signs.

Reproductive disorders in stags

Papillomatosis (warts on the penis): This is a rare condition but papillomata or warts on the penis could interfere with mating.

Reproductive disorders in hinds

Abortions: Abortions are not common in hinds, and most abortions that do occur appear to be induced by stress. There are occasional reports of late abortion caused by some of the bacteria that can cause abortion in sheep, eg Listeria monocytogenes (causing listeriosis), and Campylobacter jejuni, but these are rare. The Listeria abortions occurred after deer had grazed pasture sprayed with silage effluent.

Toxoplasmosis is a common cause of abortion in sheep, and high levels of antibodies to toxoplasmosis have been found in red hinds but it's not clear if this was associated with abortion or not. Mastitis is rare in deer.

Animal Health Factors and Cow Reproductive Performance

Infertility is defined as the inability to reproduce – i.e., cows that cannot become pregnant or bulls that cannot fertilise the cow. It may affect only a few cows in the herd or it may affect many, leading to serious economic loss. Infertile animals are usually culled but low in-calf rates and drawn out calving periods remain problems on many farms.

This section covers cow management factors that affect fertility and mating performance, including:

- Cow liveweight and condition
- Underfeeding
- Overfeeding
- Vitamins and minerals
- General health problems and injuries (such as lameness and metabolic disorders)
- Stress and stock handling

Liveweight and Body Condition

Liveweight and body condition are important for cows to begin cycling on time and hold their pregnancy. Key points include:

- Thin cows have longer PPAI than fatter ones – about 5 to 6 days longer for every 1 body condition score (BCS) unit thinner (DairyNZ Farmfact 2–1). (For more information about body condition scores, refer to the Appendix.)
- Underfeeding adds to this effect – i.e., thin cows that are poorly fed and continue to lose condition from calving to mating have even longer PPAI.
- Dairy cow condition at mating is mainly determined by condition at calving, as the average cow loses 0.5 of a BCS unit from calving to mating. Target BCS at calving of 5 for cows and 5.5 for heifers should achieve target BCS at mating of 4.5 for cows and 4.5 to 5 for heifers if they are well fed after calving.
- Once a day (OAD) milking reduces PPAI by around 8 days compared to cows milked twice a day (Dalley, 2007). Milk production declines under OAD milking so cows lose less weight from calving to mating. Thinner cows can be put in a separate OAD herd to improve their reproductive performance without milking the whole herd this way.

Underfeeding

There is no good time to underfeed dairy cows. Feeding in lactation is vital for milk production and most cows lose weight after calving as milk production rises. Peak milk output tends to coincide with mating time, causing major problems for dairy herd fertility, so dairy cows need high feed intakes from calving to mating. Many herds are fed to gain condition in winter (i.e., from drying off to calving) to have them calve in good condition and set them up for mating.

Beef cows often lose weight over winter in planned management to reduce winter feed use, this should not be confused with underfeeding. Cows that will be 'worked' over winter need to go into winter in good condition, having gained fat while cleaning up surplus feed in late spring and summer. If cows are not fat in autumn then they cannot afford to lose weight over winter or they will be thin at calving and mating (as discussed in 'Liveweight and Body Condition' above).

Key points about underfeeding effects:

- Cows underfed before and during mating have longer PPAI, take longer to get pregnant and have lower pregnancy rates.
- Post-calving feed levels should aim for good milk production in dairy cows and rapid calf growth in beef herds. This helps reduce PPAI and ensure a good proportion of cows start cycling before mating.
- Special care is needed to feed calved 2 year old heifers well, especially if they are run with older cows and struggle to compete for feed. Underfed heifers have longer PPAI and may fail to get in calf.
- Severe underfeeding in early pregnancy can reduce implantation and increase embryo losses. Maintenance feeding is ideal for early and mid-pregnancy.
- Extreme changes in the diet should be avoided in early pregnancy.
- Once established pregnancy is remarkably robust and from mid-pregnancy onwards calves are more likely to be lost to abortion diseases or trauma than underfeeding.
- Beef cows that have lost around 10% of their autumn weight over winter must regain condition before calving or they will be weak, may have trouble calving and will be more prone to metabolic problems. Four weeks of better feeding is enough to protect their health and ensure normal PPAI.

Underfeeding, calf birth weight and ease of calving

About 70% of calf birth weight is gained in the last third of pregnancy. If the cow is not fed well enough to meet her maintenance requirements plus the energy for foetus and membrane growth then she uses body fat to make up the difference and loses body condition. Feed demand tables can be used to work out how much cows must be fed (refer to the Appendix for examples).

Some farmers deliberately underfeed in late pregnancy in the mistaken belief that this makes the calf smaller and easy to deliver. This is wrong (see 'Overfeeding', below) because foetus growth is obligatory and largely genetic. *Extreme* underfeeding may reduce calf size a little but at great risk to cow health.

Underfeeding can even make calving more difficult as the underfed cow or heifer is weaker and less able to push during labour. She will have a longer PPAI and this will affect her re-breeding success.

Overfeeding

Overfeeding is not common on commercial farms but is sometimes seen on small blocks or on farms that have had unusually good pasture growth. Key points about overfeeding:

- It is almost impossible to feed a dairy cow too much between calving and mating because her energy requirement for lactation is very high. More feed is usually helpful to prevent her losing more than about 0.5 of a body condition score at this time.
- Beef cows are rarely overfed and should be offered high feeding levels from calving to mating for milk production and calf growth. They are most likely to gain weight in later spring and summer, by which time they may already be in calf.
- Most beef cows have restricted feeding in winter and lose weight, so overfeeding in mid and late pregnancy is unlikely.
- Overfeeding in late pregnancy can increase the risk of calving trouble if cows get too fat. Internal fat reduces the pelvic space for the calf to pass through, so that even a normal size calf may not pass easily.
- Two year old heifers fed to grow over winter can be fat in late pregnancy. They should be carefully watched in winter and restricted in mid-pregnancy (if necessary) to prevent them getting too fat. Growing heifers well before winter means they can grow slowly or be held at maintenance in winter without long-term effects on production or mature size. Reducing feed in late pregnancy risks metabolic problems and low colostrum production.
- Fat cows have greater risks of metabolic problems around calving due to high nutritional requirements (especially for energy) and having plenty of fat to mobilise (a risk factor in ketosis). Metabolic problems tend to increase PPAI, making these cows later getting pregnant.

Overfeeding, calf birth weight and ease of calving

There is a common belief that cows and heifers (especially) should have their feed restricted in late pregnancy to stop the calf growing too big. This is NOT correct; cows lose condition and their risk of metabolic problems rises but there is very little effect on calf size. Foetus growth is obligatory – i.e., it happens regardless of the dam's feeding level. Calf birth weight is mostly determined by genetics so the best way to reduce calf size is to use bulls from low birth weight breeds (e.g., Angus, Jersey and Murray Grey) and/or with low birth weight breeding values. Half of the genes for birth weight come from the dam, of course, so the bull is not totally responsible for calf size at birth.

Researchers wondered if reduced feeding in the first third of pregnancy, as the placenta develops, could reduce calf birth weight and calving problems but trials found that restricted feeding at this time did not affect calf birth weight either (Hickson, 2009).

Vitamins and minerals

Several minerals are important for health, liveweight gain and reproductive performance. Many are needed in small amounts (known as trace elements) but others are major minerals (e.g., calcium and magnesium). Soil levels of some minerals are low in parts of New Zealand and supplementing may be necessary for good animal performance. Vitamin levels in pasture are usually good but can be low in some seasons. Some vitamins made in the animal require good levels of other substances so deficiencies can be caused by other parts of the diet – e.g., vitamin B12 deficiency due to low cobalt (discussed below).

Specific minerals and vitamins that can affect cattle reproductive performance in New Zealand (minerals summarised from DairyNZ Farmfact 3–4):

- Calcium is vital as milk contains a lot of calcium and high production cows have high requirements. Low blood levels of Ca lead to potentially fatal hypocalcaemia (milk fever). Cows that have had milk fever have higher risks of dystocia and retained foetal membranes, and may have a longer PPAI. Supplementing with magnesium pre-calving helps prevent milk fever (as it affects the cow's mineral use) and calcium can be supplemented after calving as a direct prevention measure.
- Cobalt is essential for rumen microbes to manufacture vitamin B12 and vitamin B1, so lack of cobalt is often seen as vitamin B12 deficiency. Vitamin B12 deficiency causes ill-thrift (i.e., failure to grow) in young stock so heifers may be below target weight and not reach puberty in time for mating as yearlings. Cobalt can be applied with fertiliser or animals can be supplemented directly with vitamin B12. Talk to the vet before supplementing because many other things (e.g., internal parasites) can cause ill-thrift.
- Copper is important for growing and lactating cattle so supplements are needed in some regions. Deficiency can arise from low soil copper or high amounts of sulphur (e.g., in brassica crops) and/or molybdenum, which interfere with copper absorption. The calf gets its copper from the cow so pregnant cows may need supplements (e.g., copper capsules or 'bullets') in pregnancy to avoid swayback and other clinical deficiency signs in their calves. The vet can advise about local problems.
- Iodine is important for fertility, energy metabolism and milk production. Soil can be iodine deficient or animal iodine levels may be depressed by 'goitrogens' in the feed (common in brassica crops). Iodine deficiency or goitrogens can extend the duration of pregnancy, increase the risk of stillbirths

and reduce calf vigour at birth. Iodine deficiency is common in NZ sheep but not widely known in cattle. Injectable iodine products are now registered for use in cattle so cows grazing brassicas in winter may either be injected or given iodine in their drinking water if supplementation is required. Talk to the vet about the need for iodine if cows graze brassica crops in pregnancy, especially if iodine is needed in sheep locally.

- Magnesium (Mg) is a major mineral because cows in milk have high Mg output. Low blood levels of Mg lead to potentially fatal hypomagnesaemia (grass staggers). As Mg is required for the production of hormones that regulate calcium absorption from the gut and calcium reabsorption from bones, low magnesium also makes cows more vulnerable to milk fever. Cows that have grass staggers may have a longer PPAI. Dairy cows are often supplemented with Mg from about 3 weeks before calving until several weeks after, to prevent milk fever and grass staggers. Some beef farmers, especially with dairy-cross cows, also use Mg supplements.
- Selenium is the main mineral concerned with cow fertility. Lack of selenium can cause early and late embryonic deaths, which show up as late returns to service and empty cows at pregnancy testing. Low selenium can also increase the risk of retained foetal membranes and uterine infection post-calving, leading to longer PPAI and infertility. Vitamin E works with selenium and although it is not usually directly deficient, supplements may combine the two products.

Mineral and vitamin levels are checked through direct animal testing – e.g., using blood and/or liver samples. Blood tests and liver biopsies can be performed on live animals or liver samples can be taken from slaughtered stock at the freezing works. If testing identifies deficiency then a planned supplementation programme can be used each year. Some minerals (especially selenium) are toxic in high doses so it is important to give correct amounts and not to double up on application (e.g., in fertiliser and direct treatments of stock). The vet can advise about suitable testing and supplements.

General Health Problems and Injuries

This section looks at the effects of general health on reproductive performance.

Lameness and injuries

Pain makes the cow unwilling to graze so her feed intake, milk production and body condition all tend to fall, increasing PPAI and reducing in-calf rates. If she does cycle then she may be unwilling or unable to take part in a sexual activity. She may not be identified as in oestrus for AI or may be unable to stand for mating by a bull.

Metabolic diseases

Milk fever (hypocalcaemia), grass staggers (hypomagnesaemia) and ketosis are most common around calving time and can increase PPAI; cows may not cycle in time for AI and will be late calving next year. Supplementing with Mg before and after calving is useful for preventing milk fever and grass staggers, while calcium after calving (e.g., lime flour) helps prevent post-calving milk fever. Ketosis is prevented by ensuring good energy intakes in late pregnancy and early lactation so that cows are not forced to use large amounts of body fat.

Less common metabolic disorders include acidosis and laminitis. Acidosis occurs when the rumen becomes very acidic after high intakes of readily digested carbohydrate (e.g., lush pasture or grain). Severe acidosis can be fatal while less serious cases may reduce appetite and feed intake making the cow less likely to cycle. Laminitis, which can be caused by acidosis and other diseases such as metritis and mastitis, damages internal structures of the foot and may lead to severe lameness. In addition to increasing PPAI, the pain of laminitis can also reduce mating activity if cows do cycle.

Preventive Treatments

Animal performance is always higher when we prevent problems rather than responding after they occur. Preventive treatments can affect all stages of the reproductive cycle and include:

- Planned mineral supplementation as required under local conditions.
- Preventive animal health treatments (e.g., internal and external parasite control, vaccinations), planned with the vet’s advice and followed each year.
- Feed budgeting for good nutrition throughout the year.
- Care when buying animals – e.g., checking Tb status, buying bulls that are BVD- and EBL-free.
- Growing replacements well to achieve puberty in plenty of time and make calving easier.
- Careful bull choice for heifers to reduce dystocia risks.

Animal Handling

The more often animals are handled during the mating period then the better that handling must be to keep stock relaxed and healthy. Animals that are regularly stressed have poorer immune systems (and are more prone to infection) and may not show normal behaviour, making it harder to see cows in oestrus. Specific problems that can arise, especially on dairy farms:

- Stressed animals may suffer infections that cause longer PPAI or other reproductive health problems.
- Cows that are rushed on the way to the cowshed for milking cannot take time to look and place their feet carefully. They are more likely to suffer lameness and pain, take longer to cycle and/or avoid sexual activity.
- Cows crushed by the backing gate or forced into corners may mount other cows in an effort to avoid pressure, not as normal sexual activity. The trapped cow that is mounted has rub marks but is not in heat.
- Stressed workers are less likely to see health problems (e.g., lameness, metabolic problems) in the early stages so animal performance suffers more and recovery takes longer.
- Stressed workers are often distracted and may have little time to look for evidence of oestrus; they are more likely to miss cows that are not well marked by other animals riding.

Oestrus Detection

Oestrus (heat) detection is essential for identifying cows for artificial insemination but is also used to check cycling activity in cows and heifers before mating. The full list of signs of cows coming into oestrus, in oestrus, and after oestrus is given within the 'Cow Behaviour' section.

Signs can be confusing if you are not familiar with normal cow behaviour. The lists in Table 2 show typical behaviours seen in oestrus and behaviours that can indicate oestrus but also happen at other times (e.g., if cows are frightened or aroused). Some behavioural signs are common in cows coming into oestrus (but not yet ready for mating) or after oestrus. Some cows are aggressive or nervous all the time!

Table 2 Behaviours that may indicate oestrus

Behaviour that usually indicates oestrus	***Behaviours that could be oestrus but also happen at other times***
• Standing to be ridden = key indicator • Nervous, excitable and restless • Showing interest in bulls and/or other females in oestrus • More walking than usual (detected by pedometer or activity meter) • Sexual activity – sniffing and riding other cows in a sexually active group	• Aggressive • Alarmed or flighty • Baulking and nervous • Change in herd order (e.g., at front of herd when usually at back or vice versa) • Defensive • Reduced grazing • Territorial behaviour

Table 3 reminds us of physical signs of oestrus and signs that can be confused with indicating oestrus. Some physical signs can appear before oestrus and last until after oestrus finishes.

Table 3 Physical signs that may indicate oestrus

Physical signs that usually indicate oestrus	***Physical signs that could be oestrus but also happen at other times***
• Clear mucus from the vulva • Hair and/or skin rubbed at top of tail • Mud and rub marks on flanks (from the feet of riding cows) • Vulva more swollen, red and moist than usual	• Increased body temperature (could be fever due to sickness) • Poor milk letdown • Tail raised and back arched (can be excitement, pain or digestive problem)

Given the characteristic signs of oestrus, cycling cows can be identified by watching the herd and noting cows that stand to be ridden. Many farmers don't have time to do this so heat detection aids are commonly used. Instead of watching cows during the day, the aids are checked at milking (dairy cows) or in the paddock for beef herds.

Tail paint

Tail painting is the most common heat detection method because it is cheap and reasonably easy. Paint is applied on the back bone immediately above the tail in a strip about 60 mm wide and 150 mm long. The paint is rubbed off when the cow is ridden. If pre-mating heats are monitored then a new colour is applied when mating starts. Another colour is applied as each cow is mated or inseminated so the manager can see cows that have not cycled or which have returned to service.

Ink bubble indicators (e.g., Kamar, Bulling Beacon)

Ink bubble detectors have a capsule of paint on a patch which is self-adhesive or glued to each cow's back above the tail. Pressure when the cow is ridden bursts the capsule and the bright coloured ink is obvious. These aids are more expensive than tail paint but easier to 'read' because the bubble has either burst or it hasn't. False results can occur if cows rub on trees or other things. Colour changes can be used as for tail paint or cows might be tail painted after one cycle with ink bubble indicators.

Figure 10 Ink bubble heat detector

Scratch pad heat indicators (e.g., scratchE®)

Scratch pad heat indicators are stick-on pads with a silver top which rubs off to show a colour underneath when the cow is ridden (like 'scratch and win' tickets). They are more expensive than tail paint but easier for the inexperienced to interpret. Colour changes can be used as for tail paint or cows might be tail painted after one cycle with scratch pad indicators.

Pedometers and activity meters

Cows show up to eight times more activity when in heat so activity is a reliable indicator of oestrus and participation in sexually active groups. Cows can be automatically drafted in sheds where meters are read and matched to their electronic tag number.

Figure 11 This New Zealand Jersey cow has an activity meter and electronic identification for automatic drafting

Teaser bulls

A teaser is a vasectomised bull that behaves like an entire bull but is not fertile. Teasers are most often used to stimulate oestrus in cows before mating but can also be used to indicate cows that have silent heats. The teaser can wear a chin ball marker (described below) to mark cows when riding them or heat detection aids such as tail paint can be used.

Chin ball marker

The chin ball marker is a mating harness with a reservoir of coloured ink and a roller ball applicator under the bull's jaw, which leaves a coloured mark on the cow when the bull rides her. Chin ball markers can be used on teaser bulls to identify cows in oestrus to put up for AI or to mark cows served by entire bulls so that dates of natural mating can be recorded.

Identifying and Drafting Cows in Oestrus

If it is important to identify cows in oestrus (e.g., for AI or to record pre-mating heats) then there is no substitute for careful observation and inspection. As well as inspecting tail paint or other heat detection aids in the cowshed, good times to watch cow activity are:

- Between milkings (especially about 2 hours after milking) and at first light in the morning, to see cows in sexually active groups.
- Before and after milkings (i.e., out in the paddock).
- In the race before milking starts.

Cows should be inseminated at the next opportunity after they are seen in standing oestrus – e.g., cows seen in oestrus at afternoon milking should be inseminated next day; cows seen in oestrus at morning milking should be inseminated the same day. It is important to retrieve the cow if she is missed at drafting – getting her next time will probably be too late.

Heat Detection Errors

Errors occur when cycling cows are not detected or cows that are not in oestrus are mistakenly put up for AI. The consequences of missing a cow in oestrus include:

- The cow will not be mated for another 21 days so she will calve 21 days later next spring. She will be in milk for 21 days less than she could have been so her season's milk production is reduced next year. In a beef cow the 21 day delay means her calf is three weeks younger at weaning than it would have been.
- She may miss out on calving to AI if AI finishes before her next heat. On most dairy farms this means there is no chance of getting a replacement heifer from her and she will calve to the beef bull.
- Calving 21 days later next year will probably make her this much later every year – i.e., every year from now on she has a greater chance of missing out on AI and having a shorter lactation than she would have had. It is hard to bring a cow earlier again (i.e., calving in less than 365 days) without hormonal interventions.

Putting a cow up for AI when she is not in oestrus is less serious, although money will be wasted on unnecessary semen and insemination. The AI technician might point out cows that are not cycling (e.g., if the cervix is clearly tightly closed). The cow can be re-inseminated when she truly shows oestrus.

Mistakes happen for many reasons, such as:

- Lack of training and lack of experience in reading the signs of oestrus.
- Badly applied heat detection aids – e.g., paint in the wrong place, ink bubble detectors poorly stuck on and lost.
- Not taking enough time to check cows thoroughly.
- Poor light when checking cows – e.g., at morning milking.
- Poor drafting technique – e.g., missing a cow and not bringing it back, drafting the wrong cow.
- Stress – farm staff may put up cows that are not cycling if they are afraid of missing cows in oestrus.

Achieving Good Conception Rates

Conception rate is the percentage of cows that get pregnant when they are mated. Good conception rates are essential in condensing calving since cows take 21 days to return to oestrus. Failure to conceive means calving at least 21 days later next year, producing less milk in the dairy season or weaning a lighter beef calf than she would have if she conceived to the first mating.

Many factors affect conception rate. We will look at common problems and management factors important in New Zealand herds.

Calculating Conception Rate

The term 'conception rate' is used two different ways in New Zealand cattle industries, which can be confusing! These are:

- Many dairy farmers regard conception rate during mating as the percentage of cows that don't return to oestrus after mating. This assumed percentage overestimates the true pregnancy rate because some cows become anoestrus for other reasons. The "assumed" conception rate is the same as the non-return rate (see 'Calculations to Monitor Reproductive Performance' section).

"Assumed" conception rate = (number of cows NOT returning ÷ number of cows put up for mating) x 100

For example, suppose 450 cows were mated to AI in the first 21 days of mating. 369 of these cows do not come into oestrus again.

- "Assumed" conception rate = 369 ÷ 450 x 100 = 82 or equates to 82%

The NRR (Not Returned Date) for a given date is calculated using the Insemination figures for 21 days before. (oestus cycle for a cow) + the returns for the date in question. NOTE: if a cow doesn't get pregnant, it takes 18-22 days to return to oestus. Example below:

1st Nov 100 cows for first insemination take away 40 cows returned 22nd Nov = 60 cows. 60 cows divided by the original 100 cows = 60%.

100 – 40 = 60 then 60 / 100% = 60%

	First Insemination			Returns		Total Inseminations
	This page	To date		This page	To date	
1st Nov	20	100				100
8th Nov	30	220				220
15th Nov	12	365		3	3	368
22nd Nov	4	390		6	40	430
29th Nov	2	395		5	80	475

Beef farmers usually talk about conception rate as the percentage of cows tested pregnant from the entire herd mated. This is the "true" conception rate over the herd.

"True" conception rate = (number of cows tested pregnant ÷ number of cows put up for mating) x 100%

For example, suppose that a beef farm mated 120 cows. At pregnancy testing 6 were found not to be pregnant and 114 were in calf.

- "True" conception rate = 114 ÷ 120 x 100 = 95 or equates to 95%

Target conception rates

In an ideal world every cow would get pregnant in the mating period allowed (preferably as short as possible). In practice this is sometimes achieved in small beef herds and/or where bulls are left out for long periods, but the latter causes a long calving spread that is hard to shorten again. Practical targets are:

- DairyNZ recommends aiming for 90% of the dairy herd becoming pregnant in the first 7 weeks (49 days) of mating.
- Beef herds should achieve 90–95% conception in mixed age cows from 63 days mating.

Most farmers accept that there must be a balance between the number of empty (non-pregnant) cows and the calving spread. If we want a short calving spread, especially if we want to shorten it compared to last year, there will be more empty cows than if mating continued for longer. Inducing cows to calve prematurely in order to reduce calving spread is no longer allowed in New Zealand.

Managing Conception Rates

Apart from the length of the mating period, management factors and natural risks can affect conception rates. We have discussed abnormalities, diseases and other animal health and management effects on cow and bull fertility. Here we summarise factors that affect conception assuming that the cows *are* cycling normally and showing oestrus.

Semen fertility

Defective sperm or lack of sperm (e.g., low semen volume and/or low sperm numbers per ml of semen) can reduce conception although the bull appears physically normal and successfully mates his cows. Semen fertility can be checked by inspecting sperm under a microscope.

Basic things farmers can do to make sure semen fertility does not limit conception rate:

- Have bulls physically checked before mating (e.g., small testes indicate that a bull may have a low serving capacity).
- Have the vet check a semen sample if it is important to be sure semen is high quality (e.g., very high price bulls, bulls that will be used in single-sire mating).
- Use a team of bulls rather than single-sire mating.

- Rotate bulls so that fresh, fit bulls are available throughout mating.
- Monitor cows returning to oestrus after AI to identify possible problems with semen quality (e.g., returns to particular semen batches or bulls). Poor dilution or storage practices can reduce semen quality.

Insemination technique

If cows are correctly identified in oestrus, mated at the right time and semen quality is high then poor conception rates can indicate poor insemination technique. Commercial technicians are monitored constantly (by checking non-return rates) but farmers doing their own inseminations must review themselves and monitor returns in the second cycle of mating.

Submission rate

The submission rate (SR) refers to the percentage of cows in the herd that are mated or put up for AI in a given period. Obviously, if not enough cows are put up for mating then not enough cows will get pregnant in the desired time. Anything that stops cows from cycling or being detected in oestrus will interfere with SR, such as:

- Long PPAI – due to any one or combination of the following: poor body condition, low feeding level, metabolic problems, dystocia, retained foetal membranes.
- Inability to participate in sexual activity – e.g., lameness, stress.
- Undetected silent heats (if being drafted for AI).

Summary of Management for Good Conception Rates

Good mating results are achieved through good basic management with attention to the main factors that affect cows' ability to start cycling soon after calving, be mated at the right time and hold the conceived embryo. Key points for the dairy herd are:

- Heifers must be well grown to target weights to reach puberty on time and calve relatively easily.
- Cows should calve in good condition (BCS 5 for cows, 5.5 for heifers) and lose as little weight as possible from calving to mating.
- Pre-mating heat detection identifies cows that are not cycling – vet check and treat as necessary.
- Good records of calving dates and health treatments over calving help identify reasons for poor cow performance.
- Use records of cows in oestrus and AI details to check mating performance and identify cows with problems (not cycling, short cycles, several repeat cycles).
- Get the vet to check any non-cycling cows after 3 weeks of mating.
- Check bull health ahead of mating, observe and rotate them during mating.
- Use pregnancy test results to assess mating management. If results are not good enough then review your records to identify possible reasons for failures. Early pregnancy testing is important if cows are suspected to be anoestrus but not pregnant.

Beef herds are usually less intensively managed and few use AI but the basics of heifer growth, cow condition, nutrition and bull health remain the same. Good records are always valuable for identifying the reasons for performance that is lower than expected.

Using ram harnesses

The harness with its crayon block on the ram's brisket (pictured next page) marks the rump of ewes when the ram mounts, indicating when they are mated and whether ewes return to oestrus, i.e. they fail to conceive from the previous mating. This information is mainly used for feed planning in late pregnancy and at lambing time, as described below.

Harnesses are placed on rams before being put with the ewes and the crayon colour is changed every 7 – 10 days. Ewes mated at first oestrus are marked with a crayon colour and if not marked again ewes are likely to be pregnant. These ewes can then be drafted and mobbed and will be the first mob to lamb. This process continues until mating is complete and ewes are either drafted into mobs indicating expected lambing time or ear tags are recorded so they can be drafted into separate mobs after scanning (easier to do if electronic ear tags are used).

Ram crayons quickly give feedback about how mating is progressing. If all ewes are cycling evenly then, on average, 1 in every 17 ewes should be marked each day, with nearly 100% marked in the first cycle of mating (a few longer cycle ewes may go past 17 days). Situations that might be seen:

- Fewer ewes than expected are being marked each day. Possible causes:
    - Ewes are synchronised (naturally or using CIDRs) and are going to cycle together but haven't done so yet.
    - Ram libido or health problem (e.g., arthritis, lameness), especially in a single sire mated mob.
    - Mating is too early and seasonal breeding ewes are not cycling yet.
    - Hoggets being mated have not reached puberty.
- More ewes than expected are being marked each day. Possible causes:
    - Ewes are synchronised (naturally or using CIDRs).
    - Ewes have been mounted despite NOT being in oestrus. This can happen if animals aren't free to move away, e.g., ewes trapped in a corner of the yards, but is unlikely to happen in the paddock.
- Ewes are marked with two or more colours. Possible causes:
    - Ewes were cycling when crayons were changed and mated at least twice, once with each colour.
    - Ewes did not conceive when mated the first time and returned to service. This could be due to mating failure (e.g., ram mounted but failed to serve), fertilisation failure (sperm did not fertilise a healthy egg) or conception failure (including failure of the embryo to implant)
    - Ewes had early embryonic deaths and the pregnancy was lost in time for the ewes to return to service before the rams were removed. Selenium deficiency and campylobacter infection can cause early embryonic loss.

By changing the crayon colour every 7 – 10 days the actual date of lambing can be more closely predicted. That is, by recording what dates each crayon colour is used and what colour the ewe is marked with, the lambing date can be estimated (each colour group will typically lamb within 140 – 160 days of when the crayon colour was used).

Knowing the likely lambing date enables feed management in the last three weeks of pregnancy and set stocking to be more closely managed. This is especially important when feed is in short supply and/or for multiple bearing ewes. Supplementing multiple bearing ewes, especially those having triplets, with high energy/low bulk feed, such as barley or sheep nuts, can help prevent ewe metabolic disorders and improve lamb/ewe survival. By having a better idea of lambing date, less of the expensive supplement is used on ewes likely to lamb later. Also ewes can be set stocked progressively as they approach lambing and the rest of the flock can continue to be rotationally grazed (which allows higher pasture utilisation), especially when pasture is in short supply. More precise knowledge of the lambing date is also of benefit when intensively shepherding flocks for maximum lamb survival, especially for high performance flocks.

Any unmarked ewes after rams are removed from the flock may be assumed barren but should be checked at scanning if confirmation is required. Crayon marks can be faint and hard to see, especially if harnesses were poorly fitted, crayons were badly worn (e.g., used for more than 7–10 days and/or each ram served large numbers of ewes) or small ram hoggets mated large ewes (putting little weight on the crayon when mating). Soft crayons should be used in cold regions. Ewes with multiple crayon colours have cycled and been mated but have not successfully conceived at earlier matings. They may or may not be pregnant but pregnancy scanning will confirm their pregnancy status.

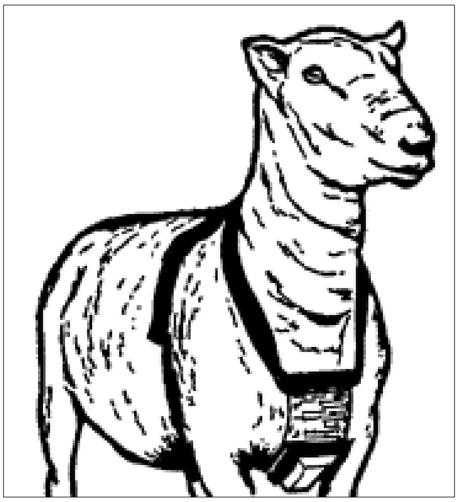


Figure 11 Left Position of Harness on Ram, Right ram mounting ewe

Note: As the ram mounts the ewe to mate the crayon colour rubs off onto the rump of the ewe

Right Image retrieved from http://woolshed1.blogspot.co.nz/2009/01/sheep-farm-husbandry-reproduction-and.html

Left Image retrieved from http://www.infovets.com/books/smrm/B/B538.htm

Good harnesses, carefully fitted to each ram, cause few problems. Potential disadvantages of harnesses, particularly on extensively managed hard hill country, can include:

- harnesses working loose and being lost
- snagging the ram on a stump or similar – at best, lost mating opportunities and at worst, a dead ram if not checked regularly
- extra labour required to put harnesses on, change crayons if required and check rams are not snagged or harnesses slipped, etc.

- ram stress – although harnesses should not interfere with mating the extra handling may increase stress levels

Harnesses should fit comfortably, holding the crayon in the centre of the ram's brisket against the skin (but not tight) when the ram has his head up. The crayon will appear to hang a little loose when the ram grazes. Harnesses should be inspected frequently to ensure that they do not cause chafing of the skin and to check crayon wear. They should not be left on longer than necessary. They should be removed if they cause injury and adjusted if they appear to be causing discomfort or the crayon does not sit correctly.

Situations where ram harnesses may be beneficial include:

- managing pre-lambing feed levels on intensively managed sheep farms
- intensive shepherding at lambing
- proving a ram has been working, particularly in single sire mating circumstances
- noting returns to service which may indicate the previous ram was working but infertile, especially in single sire mated mobs
- where it is important to know which ewe has been mated by which ram – usually of more importance to stud breeders than commercial farmers

Using pregnancy scanning information

Scanning is done by a trained operator using ultrasound equipment to see the developing foetuses in the ewes. Ewes are usually marked with spray raddle to show how many lambs they are carrying, e.g., red marks for ewes not in lamb plus different colours for singles, twins and triplets. The scanning operator keeps a record of each result to calculate the scanning percentage.

Scanning gives advance warning about feed requirements at lambing and expected lamb numbers for sale. Ewes carrying multiples can be drafted out for preferential feeding. This is especially important for ewes carrying triplets. Some farmers do not get triplets marked by the scanner but this usually means triplet survival will be lower as ewes cannot be fed accordingly.

Scanning results give feedback about mating management. Ewes with good liveweight and body condition should scan better than thinner/lighter animals. An unexpectedly low scanning percentage given ewe weight and condition may indicate a health problem, e.g., selenium deficiency or embryonic losses due to campylobacter. Veterinary advice should be sought to identify the source of the problem and treat or prevent it in future.

Individual animal history can be used for breeding and culling decisions. For example, a heavy fat ewe that repeatedly has a single lamb eats a lot but produces little; she can be culled or put to a terminal sire so her daughters are sold. Farmers who want few triplets can do the same with ewes repeatedly scanning triplets.

Test Yourself #3

1. Describe the use of tail paint for heat detection.
2. Describe the use of a ram harness for heat detection.
3. Briefly describe two other heat detection aids.
4. Why does it matter if a cow in oestrus is missed when drafting for AI?
5. How can we tell if a bull has a semen quality problem?

Record Keeping for Cow Reproductive Success

Good record keeping increases the chances of reliable results from cow mating. It is impossible to remember everything that happened but records may show trends in performance or highlight individual animals with problems that can be fixed. Good records can also help the vet to solve problems that arise or explain why certain animals have poor performance.

Calculations to Monitor Reproductive Performance

Monitoring mating and its results is an essential part of reproductive management, especially on the dairy farm. The manager can check that expected events happen (e.g., enough cows are mated each day) and that results are adequate (e.g., most of these cows don't return to oestrus).

Good monitoring means poor performance can be recognised early enough to identify the problem and take corrective action before mating is too far advanced. Lack of monitoring may mean the manager simply wonders what went wrong far too late to fix it – e.g., when the in-calf rate is much too low.

Submission rate (SR)

This is the proportion of cows seen in heat and submitted for AI or natural mating in a given period. It is usually expressed as the percentage of cows in the herd inseminated or mated in a stated period, usually the first 21 or 28 days of the AI programme.

SR = (number of cows put up for mating ÷ number of cows in the herd) x 100

For example, suppose 951 cows from a herd of 1200 were put up for mating in the first 21 days of AI. A further 133 were mated in the next 7 days, *not* counting cows returning to heat after mating in the first 21 days.

21 day SR = (951 ÷ 1200) x 100% = 79.3%

28 day SR = (1084 ÷ 1200) x 100% = 90.3%

Target submission rates

Successful mating and condensed calving requires high submission rates.

- DairyNZ's Farmfact about dairy cow mating management (Farmfact 2–5) recommends a target submission rate of 95% in the first 28 days of mating and that 100% of the herd should be submitted for mating at least once within 7 weeks of the start of mating.
- The DairyNZ InCalf book states that top farmers achieve a 21-day submission rate of around 90%.

Achieving 90% submission in the first 21 days means mating an average of 4.3% of the herd each day but mating typically starts slower than this and speeds up over time. Most NZ dairy farms do not meet these targets and many are 10 to 20 percentage points lower (e.g., 70 to 80% submission in the first 3 weeks of mating).

High submission rates mean the AI period can be shorter (assuming most mated cows conceive). Poor submission rates mean AI must continue for longer to generate enough replacement heifers.

This year's calving spread has a major influence on next year's expected spread. Late calvers (i.e., calving within 40 days of the planned start of mating) are unlikely to cycle in the first 21 days of mating.

Non-return rate (NRR)

The NRR is the proportion of cows NOT returning to heat after mating. It can be defined in several different ways, depending on exactly what is being measured. For example:

- **NRR**: "The percentage of inseminations where the cow did not return to heat within 24 days after the insemination." (DairyNZ InCalf Book)
- **NRR (18-24 days)**: "A form of non-return rate used by breeding companies to monitor AB technician performance that excludes both short returns (<18 days) and long returns (>24 days)." (DairyNZ InCalf Book)
- **49-day NRR**: "The percentage of cows inseminated in the first 21 days of AI that do not return to service by day 49 of AI." (A common form of NRR used in the NZ dairy industry)
  - The cows obviously have to have time to show another oestrus (if not pregnant), but we can start calculating early NRR after about 6 weeks (42 days) of mating.

NRR = (number of cows NOT returning ÷ number of cows put up for mating) x 100

For example, suppose that 340 cows were mated to AI in the first 21 days of mating. Within 49 days of starting inseminations, 88 of these cows come into oestrus again.

- Cows NOT returning = 340 mated minus 88 that returned = 252
- NRR (49 days) = (number of cows NOT returning ÷ number of cows put up for mating) x 100
  = (252 ÷ 340) x 100
  = 74.1%

Target non-return rate

The target 49-day NRR should be around 75% for cows mated to naturally occurring oestrus. The NRR is usually lower if cows were treated with CIDRs or other hormone treatments to make them cycle.

Note that NRR is higher than the true pregnancy rate in the mated cows since it includes cows that have stopped cycling for other reasons (e.g., returned to anoestrus or suffered an animal health problem). True conception rate is often up to 10% less than NRR; the true pregnancy rate to first insemination (based on pregnancy testing 6 weeks after insemination) averages around 60–65% (DairyNZ Farmfact 2–1).

Monitoring NRR

AI service providers (e.g., LIC) continually monitor NRR on client farms as indicators of semen fertility and technician performance. The earliest indicator of technician performance is the 18-24 day NRR; if this NRR is low it may be a warning of a low conception rate for the whole AI period. Some of the things that may be learnt from client farms' NRRs include:

- If several farms using the same technician have high rates of cows returning to service then there may be an AI technique problem. Poor technician performance is not acceptable so the technician may be withdrawn from work and re-trained.
- If lots of cows return on one or two farms then this might indicate that those farms have problems with oestrus detection.
- If lots of cows return after insemination with semen from a particular bull or batch then this is probably a semen quality or storage problem. The semen will be withdrawn from use and farmers may be offered free replacement semen (but the cows will still be later calving than they should have been).

Calculating Calving Date

The expected calving date of a cow is 282 days from the mating date. Lots of popular farming notebooks (e.g., from PGG Wrightson, RD1 and other retailers) and the calving record books provide tables showing expected calving date for a range of mating dates. The table below is an example. If the exact mating date is not listed you can find the closest date and adjust the expected calving date accordingly. For example, a cow with a mating date of 28 July would have an expected calving date of (28-23) + 1 May, i.e., 6 May; a cow with a mating date of 20 December would have an expected calving date of (20-10) + 18 September, i.e., 28 September.

Table 4 Look up table for expected calving date

Mating Date		***Calving Date***	
9	July	17	April
23	July	1	May
6	August	15	May
20	August	29	May
3	September	12	June
17	September	26	June
1	October	10	July
15	October	24	July
29	October	7	August
12	November	21	August
26	November	4	September
10	December	18	September
24	December	2	October
8	January	17	October
22	January	31	October
5	February	14	November
19	February	28	November

5	March	12	December
19	March	26	December

If you don't have a table to look up then you can work out the expected calving date using "plus 9 months and 9 days", as follows:

- Write down the mating date as "day/month".
- Add 9 to the day and 9 to the month. (It is usually easier to subtract 3 from the month, unless the cow was mated in January, February or March.)

For example, suppose a cow was mated on the 15th of November.

Mating date = 15/11
+9/-3
Calving date = 24/8 (i.e., 15th plus 9 = 24th; 11th month minus 3 = 8th month)
= 24th August

What if the date goes past the end of the month? Let's try it and see. Suppose the cow was mated on the 25th November.

Mating date = 25/11
+9/-3
Calving date = 34/8

But we know there is no such day as the 34th of August! August has 31 days, so this must be the 3rd of September. (Check Table 4 above and you will see we are right.)

What if the cow was mated on 3rd January? This time it is easier to add 9 to the month, rather than subtracting 3.

Mating date = 3/1
+9/+9
Calving date = 12/10
= 12th October

Using predicted calving dates

Forecasting calving dates helps the manager to plan spring management and cow feeding. Typical planning issues include:

- Condensed calving may require extra labour to pick up calves, draft calved cows into the colostrum mob and feed calves.
- Long drawn-out calving may require less labour but feeding and separate cow mobs are more complicated to organise.
- Late calving cows can be brought back from grazing later or fed separately.

Sheep - Factors affecting conception rates

Technically, conception rate is the percentage of ewes that get pregnant at mating. Most farmers want all the ewes to conceive but the ideal proportion of multiples varies depending on location and farm type. Scanning percentage is the number of lambs present at scanning divided by the number of ewes mated. Farmers can use this to compare results from different management strategies and plan spring management for lambing time. Both conception rate (the number of ewes pregnant) and scanning percentage (the number lambs carried per ewe) can be affected by management.

Ovulation rate, the number of eggs shed from a ewe's ovaries during ovulation, sets the potential lambing percentage. If a ewe sheds one egg prior to service she can only produce one lamb no matter how fertile the ram is. Shedding two eggs allows for the potential of twins, three eggs for triplets and so on.

Ovulation rate is governed mainly by:

- breed
- age
- liveweight and body condition at mating
- liveweight gain prior to mating

Within a breed and age group (and assuming good health), the greatest influences on ovulation rate and resultant number of lambs conceived are:

- body condition
- ewe liveweight at mating
- increase in liveweight leading up to and during mating (flushing)

Breed

Some breeds, such as Finnish Landrace (also called Finn) and East Friesian, typically have higher ovulation rates, conception rates, multiple birth rates and lambing rates than traditional breeds such as Romney. Also Finn and East Friesian-crosses start cycling earlier and have a longer breeding season than most other breeds.

Age

In general, hoggets have lower ovulation rates than older ewes. Two tooths also have lower ovulation rates than older ewes, especially if they were not lambed as hoggets. Peak ovulation rate is at about four years of age and declines in old age, around nine years old.

Liveweight and body condition score (BCS)

Liveweight measures body size and is an indication of body condition (which is more directly measured by body condition score (BCS)). The mature liveweight of a breed or flock typically indicates the minimum mating weight required to optimise reproductive performance. For example, a mating weight of 65kg may be suitable for a particular line of Romney ewes but would be too low for a line of Finn x Romney crossbreds which may need to be 75kg to be in the best condition for mating.

Weighing is usually quicker than assessing BCS, particularly for large flocks, but it is a poor indicator of condition if ewe size varies. The largest ewes in most flocks are often about double the weight of the lightest, i.e., a flock that averages 75 kg can range from 50 to 100 kg. The lightest ewes are *not* always the thinnest; ewes at BCS 3 can span a range of 20–30 kg if their frame size differs.

Assessing body condition score is a ‘hands on’ task’, particularly if sheep are woolly. It is not possible to visually assess BCS with a layer of wool disguising actual body contours. Running a hand over the spine, and over and under the horizontal processes (see diagram below) is the best way to assess BCS. If the farm has time to condition score OR weigh ewes in summer (but not both) then checking BCS, drafting the thinnest ewes and lifting their condition is the best choice.

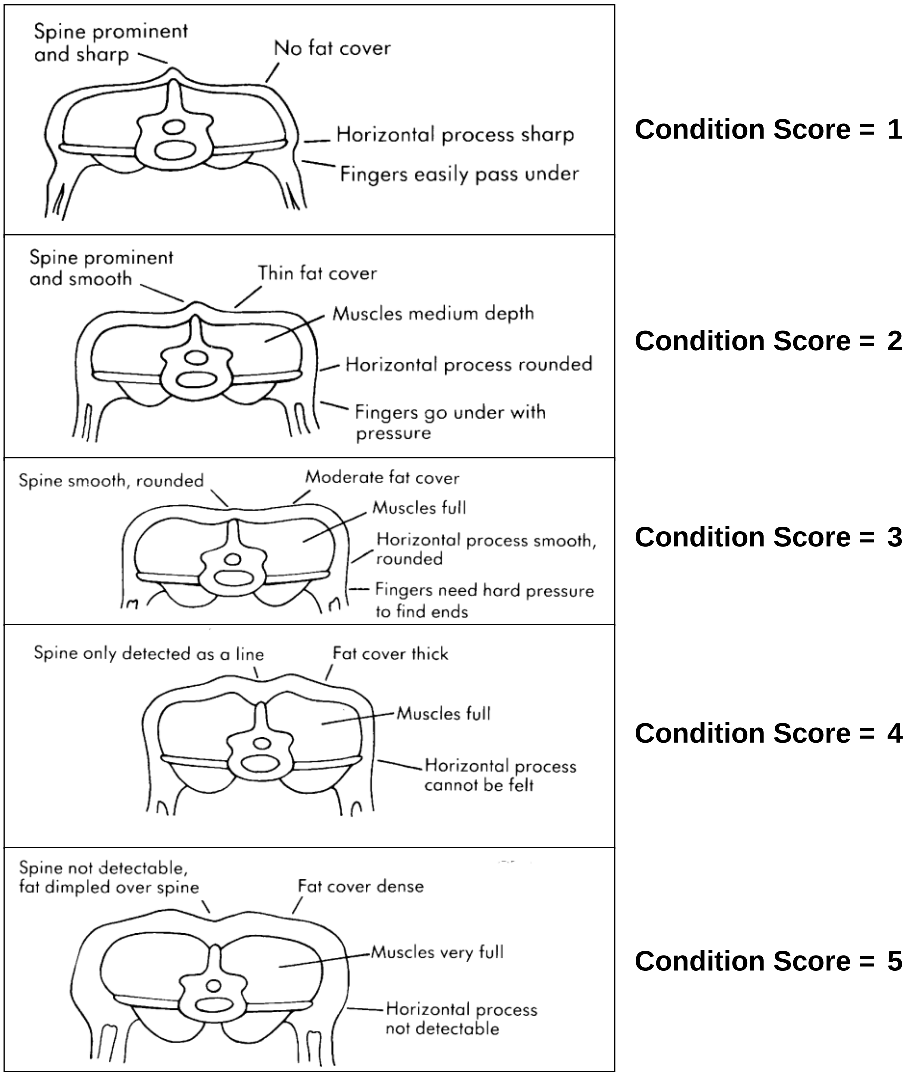


Figure 12 Sheep condition at different body condition scores

Source: ‘How to Resources’ on www.beeflambnz.com

Ewe liveweight at mating

Heavy ewes typically have a higher percentage of multiple ovulations than light ewes (of the same breed and age). This illustrates the 'static effect' of liveweight. In general, ovulation rate and lambing percentages increase by 5–10% for every 5 kg increase in the flock's mating weight.

Table 5: Static effect of adult ewe liveweight on the percentage of multiple ovulations (i.e. ewes that shed more than one egg)

Pre-flush liveweight (kg)	*6-week flush liveweight change*	*Ewe liveweight at mating*	*Multiple ovulations (%)*
45	No change	45	52
57	No change	57	78

Source: adapted from Maximising Ewe Performance - www.enterprisenorthland.co.nz

Table 5 clearly shows that lighter ewes at mating, which have had no increase in weight in the six weeks prior to mating, have lower ovulation rates than heavier ewes. The ideal ewe liveweight at mating varies with ewe age and breed. Hoggets of most breeds should be at least 40–45 kg at mating to ensure they have attained puberty, will be cycling and are grown out enough to lamb and re-breed successfully as two-tooths.

Change in ewe liveweight prior to mating - flushing

Rapid liveweight gain (e.g. 0.5 – 1.0 kg per week) in the three to six weeks prior to mating, commonly called 'flushing', improves ovulation rate. Liveweight loss reduces ovulation rate. This illustrates the dynamic effect of liveweight and is illustrated in Table 6.

Table 6: Dynamic effect of ewe liveweight on ovulation

Pre-flush liveweight (kg)	*6-week flush liveweight change*	*Ewe weight at mating*	*Multiple ovulations (%)*
51	Gained 6 kg	57	87
51	No change	51	70
51	Lost 6 kg	45	47

Source: Maximising Ewe Performance - www.enterprisenorthland.co.nz

In general, for every 1 kg liveweight gained during flushing, lambing percentage increases by 3%. Typically, the increase in ovulation rate of heavier ewes in response to flushing is lower than that of lighter ewes. This reflects the importance of static body weight/condition on ovulation rate, i.e. heavier ewes already have a higher ovulation rate than lighter ewes.

Hoggets are not usually flushed but need to be continually growing throughout mating and pregnancy to achieve target mating weights as two-tooths.

Flushing is not a substitute for poor liveweights. However it can be of greater significance during difficult seasons where feed in late summer and autumn is restricted. For example, a summer drought could result in ewes with a BCS of 2.5 three weeks prior to mating. Flushing these ewes during the three weeks before mating starts can improve their ovulation rate.

As the entire purpose of the flushing exercise is to ensure more eggs are shed at ovulation, it should start before the rams go out. It takes time for the ewes to respond to the extra feeding and as the average interval between oestrus is 17 days it is necessary to start more than 17 days before mating. The general recommendation is to start flushing no less than three weeks before mating and continue for the first three weeks of mating if possible.

Ewe liveweight during mating

Flushing of ewes should continue for the first three weeks of mating to optimise ovulation rates. Ewes should not lose weight during mating. Good pasture cover also ensures that ewes are not busy searching for feed which can decrease contact with rams.

Typically 80% of ewes are in lamb by the end of the third week of mating and only 20% conceive during the next five weeks. This means there is less chance of stimulating the ovulation rate or improving twinning conception by flushing after three weeks with the rams.

Although ewe weight gain is not necessary after week three it is still essential that ewe liveweight is maintained. Ewes should not lose the weight gained but be fed to maintain the liveweight they have attained.

Ewe body condition score

Body condition is increasingly recognised as essential for ewes to perform near their genetic potential. A flock of medium-framed ewes in good condition may outperform a flock of larger-framed thin ewes, even if the latter are heavier.

Average liveweight or condition does not tell the manager much if there is a wide range of animals, especially at the lower end. The poorer performers within a flock tend to be the thinner 'tail end' and concentrating on these animals may increase profit considerably. Averages can be misleading if individual animals' results cover a wide range and it is most important to pay attention to the thinnest animals, which are not necessarily the lightest. For example, an average mating weight of 65 kg may sound acceptable but if 15 – 20% of the flock has BCS less than 2.5 then the flock as a whole will underperform markedly.

Increasing the feed levels of the bottom end of the flock can make a large contribution to the overall number of pregnancies. This means separating the lower weight or BCS ewes into mobs that can be offered adequate quantities of high quality feed to lift liveweights. Suitable feeds include good quality, green leafy pasture (if available), high quality silage or concentrates such as barley or sheep nuts. Low liveweights may also indicate health problems such as high worm burdens, mineral deficiencies and/or chronic diseases. It is essential that any health issues are identified and treated to maximise gains from any extra feed offered.

Ewes should have a minimum BCS of 3 at mating, which means most of the flock will be BCS 3 to 4. BCS should be assessed early enough for thinner ewes to reach BCS 3 by mating, preferably allowing at least 8 weeks for condition gain. All ewes should be assessed individually and ewes with BCS less than 3 should be drafted out for preferential feeding on longer and better quality pasture or supplemented with higher energy feeds (e.g., barley). If feed is tight then concentrate on ewes below BCS 2.5.

Thin ewes may have underlying health problems, especially internal parasites, foot and/or tooth problems. The vet can advise about likely responses to worm drench or other treatments.

There is no benefit in having ewes fatter than BCS 4. Fat ewes (BCS 5) can conceive and many are likely to have multiples but they have a high risk of metabolic problems such as ketosis (sleepy sickness) in late pregnancy, especially if feed is restricted. Metabolic problems increase ewe deaths and dead or weak lambs. Very obese ewes may not cycle or may have lower conception rates but this is uncommon in commercial flocks.

Ram body condition score

Ram BCS should be 3.5 – 4.0 at mating. Rams not in this condition ten weeks prior to mating need to have access to sufficient high quality feed to lift body condition to this ideal. High protein feed supplements (e.g. high protein, grain based, sheep ‘nuts’ or high quality silage) can increase sperm production and testes size particularly if rams have been on a low protein diet, for example, if drought conditions exist.

Nutritional changes affect testicle size much more rapidly than is reflected in liveweight or general body condition. Because of this, you need to check all aspects of the ram’s reproductive health before mating. Just checking body condition is not an adequate indicator of a ram’s reproductive ability.

As ram feed intake is generally lower over the mating period they need to be in good condition (i.e., BCS 3 or a little more) at the start of mating to allow for any weight loss that is likely to occur. On the other hand, overfat rams may tire easily, struggling to seek ewes in oestrus or keep up mating behaviour, and consequently have a lower mating rate (number of ewes mated/cycle). Overheating may reduce their sperm quality and fertility. Overall, rams need to be fit and in good condition but not fat.

Fecundity vaccines

Androvax and Ovastim are fecundity vaccines, i.e., they increase the rate of multiple births by increasing ovulation rate in treated ewes. Lambing is typically increased by around 20% (ranging from no response to a 50% increase). They stimulate antibodies in the ewe which create a change in hormonal balance and alters the function of the ovaries, increasing the number of eggs shed. The treatments only alter ovarian activity for a short period. Best results are obtained from ewes with body condition scores around 4.0.

Hoggets should not be given fecundity vaccines as they are typically under enough stress just raising one lamb.

A fecundity vaccine is a tool for very good management situations. It is NOT a substitute for poor management. It may be considered where normal lambing percentage is around 100 –140%, when most of the response will be as twins. Where ewes are already achieving 150% it should not be used, as much of the response will be as triplets or quads, which are likely to have poor survival rates. For the same reason, the vaccine should not be used in high fecundity breeds like the Finn.

Possible benefits of using fecundity vaccines include:

- a similar number of lambs can be produced from fewer breeding ewes
- less capital is tied up in breeding stock, i.e. if lambing percentage is high then less ewes are needed to produce a specific number of lambs than with a low lambing percentage
- fewer ewes means fewer replacements and rams will be required
- lambing percentages can be changed simply by deciding whether or not to give a booster in any year
- it may be used to boost flock fecundity if there is a lack of feed for flushing because of a dry season
- it may be used to boost fecundity where ewes are mated early (i.e., conceiving to their first or second oestrus of the season)

Timing of ram introduction and ram:ewe ratios

When to introduce the rams

Ideally rams should be introduced to the ewes three to nine days before the next oestrus or heat period begins, towards the middle of the breeding season, around the third oestrus cycle. The 'ram effect' (see page 24) will usually start ewes cycling within three to nine days of ram introduction in mid-season so synchronisation is not usually necessary unless mating is early. In practice, to meet market demand, rams are often introduced just before the second oestrus period.

If less than 80% of the ewes lamb as a result of mating at the first cycle after rams are put out, lambing will be spread out. This also affects weaning time and the uniformity of lamb weaning weights and target slaughter weights.

What ratio of rams to ewes should be used?

Rams that are well nourished, disease free, physically fit and mating under ideal conditions are capable of successfully serving large numbers of ewes. Typically, for rams in good condition, ram:ewe ratios can be as high as 1:150 to 200 for mixed age ewes, 1:150 for two-tooths and at least 1:100 for ewe hoggets. (Note: A ram:ewe ratio of 1:200 means you put out 1 ram for every 200 ewes, i.e., if you had a flock of 600 ewes you would need 3 rams.)

Although rams with physical defects can be identified and culled, factors such as desire (libido), mating ability and serving capacity (stamina) are more difficult to measure. There is often a considerable variation in these factors between rams within a flock. The ram:ewe ratio needs to allow for those rams that will not successfully mate with their allocated number of ewes. Using a mix of older, experienced and younger, inexperienced rams can help overcome variation in mating performance. However this may result in young rams mating less ewes if the ram:ewe ratio is high (e.g. 1:100) and the older rams perform well.

Hoggets are only in heat for a short period of time compared to older ewes, possibly as little as 4 – 6 hours and may also exhibit irregular oestrous activity. As a result, they need a higher ram:ewe ratio (e.g. 1:100) than older ewes. It is also preferable to use experienced rams with hoggets rather than young, inexperienced rams. Two-tooths ewes, not mated as hoggets, will also be inexperienced. Ideally they should be separated from older ewes and mated with sexually experienced rams at around ratios of 1:150.

With low ram:ewe ratios (e.g. 1:200) there is a risk of one ram becoming temporarily infertile or injured and incapable of serving. This could result in fewer ewes mated per cycle and an undesirable long spread of lambing. Keeping a close eye on ram mating activity should be able to pick up problems such as this and the injured or poorly performing ram can be replaced.

Using too many rams may also reduce the number of ewes mated per ram. It can result in excessive competition between rams for the ewes as they come into heat, spending more time fighting instead of mating. Conception rates, subsequently, may be lower than expected.

Other factors influencing the ram:ewe ratio for individual farms include:

- topography and paddock size
- A higher ratio is required on broken, hilly country and where the paddocks are large. This is because the rams have a greater area to cover and may have less chance to interact with ewes. With a rotational grazing regime the situation is different because the flock generally knows when it is to be shifted, and rams and ewes mix in the vicinity of gateways in anticipation of fresh feed.
- the age of the rams
- More experienced rams are usually able to mate more ewes per cycle than young, first-time-out rams.
- whether the farm is run intensively or extensively
- Intensive farms running a relatively large number of small mobs of ewes will generally have a higher ram:ewe ratio overall because each mob will require their own rams. This is also likely to be the case when parentage needs to be recorded, e.g. stud breeders.
- the amount of labour available
- Low ram:ewe ratios generally require less labour than higher ratios because the ewe mobs are generally larger and there are usually less mobs to supervise.

Deer - Factors affecting conception rates

Stags

In most cases, herd sires should be 3 years or older. Single sire mating, that is one stag with a group of hinds per paddock, is the usual mating system on deer farms. A follow-up stag can be used for the last 2 or 3 weeks of the breeding period.

Always remember that stags are dangerous during the rut and should be treated cautiously.

The stag should be introduced in January. Hinds generally aren't ready to mate much before the 20th March, but early stag introduction helps ensure that calving dates are as early as possible to make best use of the spring flush of pasture.

The polygamous nature of red, fallow and Pere David's deer suits them well to farm breeding. Among these species it is wise to allocate one stag to 30 to 40 hinds, although this figure depends on the age of the stag and the nature of the terrain. It would be unwise to leave a yearling stag with more than 10 hinds whereas a 6-year-old stag could probably handle 60 hinds. Up to 100 hinds have been run successfully with a single highly valued adult stag. On very rough hill ground, in large enclosures and where fog, wind and rain often accompany the rut, then as with hill sheep, more stage must be used.

(Haigh and Hudson [1993] consider that for practical purposes mature red deer stags can be expected to mate with and fertilise up to at least 50 hinds in a 6-week period, and wapiti stags 20 to 25. Much higher numbers of hinds per stag have been used but the calving season may then be spread out.)

It is wise to make a subjective assessment of whether the stag is actually working and if he appears to lose interest after a week or two then he should be replaced. This can be easily carried out by use of a dart gun. Raddle harnesses have been used but unless the hinds are extremely tame it is almost impossible to see the slight mark left by the crayon. A clue as to whether a hind has been recently served is provided by the hair on the rump. If she has been mated in the previous few hours, the hair is usually pushed forward and ruffled above and forward of the tail.

In large paddocks, or where cover is broken, several sires can be used, as the herd will split into several groups with a stag in each.

If possible, it’s best to keep empty paddocks between mating groups on the farm. Along with single sire mating, this strategy helps to stop stags from fighting.

It is important to note that young stags if kept in a paddock alongside an experienced older stag may not indulge in any breeding behaviour even if hinds are coming onto oestrus. Also, where mating groups with red and wapiti stags are kept in adjacent paddocks, the wapiti stag may not show any mating behaviour. It seems that the aggressive display and roaring of a mature red deer stag somehow suppresses the less aggressive wapiti and younger red stags. It would seem wise to keep the breeding groups out of sight of one another. The stags should be separated by two fences across an alleyway.

Hinds

Hinds mated at 16 months of age need to reach a minimum live weight of 70% of their mature weight (mature weight of NZ red hinds is typically 100 to 110 kg) to achieve 90% calving or better.

As with sheep and cattle, adequate feeding is needed to ensure that hinds calve every year.

Yearling hinds should be mated separately from mature hinds to avoid bullying.

During the breeding season, red hinds will cycle every 18 days, and wapiti cows every 21 days.

It’s best to concentrate fawning into as short a period as possible because this makes management easier. The span of calving dates can be reduced by early weaning and a rising plane of nutrition for breeding hinds.

To ensure calves are born pre-Christmas from red hind/red stag matings, remove the stag around 7th May (that is, 233 +/- 5 days before 25th December). For red hind/wapiti bull matings, remove the bull around 1st May (that is, 242 days +/- 5 days before New Year’s Day).

Because the most conspicuous part of the rut, the roaring and inter-stag aggression, precedes conception, many people working with deer imagine that mating takes place earlier than it actually does. It is therefore worth bearing in mind that the 231 day gestation of red deer means that an April 1st mating would produce a November 20th fawn, which is early.

Pregnancy diagnosis

Pregnancy can be confirmed in various ways:

- Ultrasound examination using a scanner with a 5 MHz linear transducer on a rectal probe from 35 to120 days after mating (this procedure requires good restraining facilities to ensure that the deer and equipment are not damaged during the examination).
- Blood (serum) tests for hormones or pregnancy-specific protein are theoretically possible but are not generally available.

Ultrasound pregnancy diagnosis may be most useful following embryo transfer (ET) and artificial insemination (AI) programmes. By using the tables of measurement that are now available, the foetuses can be very accurately aged. This means that the sire of fawns born can be identified because pregnancies resulting from follow-up stags will be considerably younger than those resulting from ET or AI. In a good handling situation it is often possible for the skilled operator to scan over 50 hinds an hour.

Characteristics of the Reproductive Cycle of the Various Breeds of Deer Farmed in NZ

Red Deer (Cervus elaphus)

Characteristics of Red Deer

Rutting season	Late March - April
Nature of oestrus	Seasonally polyoestrus, April - August. 18.8 +/- 1.7 day cycle. 12 - 24 hours duration
Gestation period	231 days (range: 226 - 238)
Calving	Late November - December (occasional calves born as late as March)
Number of young	One. Weight 8.5 kg
Sexual maturity	16 months

Wapiti (Cervus elaphus nelsoni)

Characteristics of Wapiti

Rutting season	March - April
Nature of oestrus	Seasonally polyoestrus. 21 day cycle
Gestation period	255 days
Calving	November-December
Number of young	One. Weight 18 kg
Sexual maturity	16 months

Fallow Deer (Dama dama)

Characteristics of Fallow Deer

Rutting season	April-May
Nature of oestrus	Seasonally polyoestrus mid April - August/September 22 +/- 1.3 days cycle.
Gestation period	234 days
Calving	December
Number of young	One. Weight 4.5 kg
Sexual maturity	16 months

Test Yourself #4

1. Work out the expected calving date for cows mated on the following dates.
   a) 13th October
   b) 28th November

2. Work out the expected fawning date for deer mated on the following dates.
   a) 13th March
   b) 28th March

3. Work out the expected lambing date for sheep mated on the following dates.
   a) 13th March
   b) 28th March

Reproductive Interventions

Elective reproductive procedures (ERPs) or Assisted Reproductive Technologies - these are names given to some modern technologies that can be used to improve the genetic quality of livestock.

Semen collection

Semen is collected from bulls using an artificial vagina (AV). The bull is allowed to mount a heifer or cow that is held in a special crush and his penis is deflected into the AV. The semen can be tested and evaluated before being inseminated into many cows if required.

Many organizations such as LIC and AM Breed and breed groups offer chilled or frozen semen from proven bulls for sale and now can even offer sexed semen. Farmers can also have their own animals' semen collected and use this fresh on farm or have it stored frozen in liquid nitrogen for future use.

For a look at how bull semen is collected, tested and stored, check out the first part of this video

https://www.ruraldelivery.net.nz/stories/Elite-Genetics-at-LIC

Artificial insemination

Artificial insemination (AI) is the most common of the procedures. This procedure means that semen from superior proven males can be used to inseminate females on farms that are a distance from the male and the semen from the male can be more widely used than would be possible by natural mating.

A trained technician deposits a chilled or frozen semen sample direct from a pipette in the vagina through the cervix and into the uterus. The technician uses an arm in the rectum to help guide the pipette through the cervix.

As well as improving the genetic quality of livestock, the procedures can be used for sire referencing schemes. They can be used when males are unable to serve large numbers naturally, and to bring in new genetic material to prevent in-breeding, and when there is no suitable sire. Most dairy herds use AI sires for their heifer replacements to improve the genetic merit of the future herd.

Synchronise oestrus

Several techniques can be used to encourage cows to cycle if too few show oestrus before mating starts on the dairy farm. Some can also be used to synchronise oestrus – i.e., to get many cows to show oestrus at the same time.:

- Prostaglandin treatment can be used to destroy the corpus luteum and get cows to cycle again. It is used for synchronisation, especially in heifers (e.g., to make AI easy to manage in one or two visits rather than detecting oestrus and inseminating daily).

- Controlled internal drug releasers (CIDR devices) placed in the cow's vagina release progesterone and stop the cow from cycling. The CIDR is placed in the cow for several days and then withdrawn (often an injection of oestrogen is given at this time); cows show oestrus after the CIDR is removed.

CIDRs can be used to start anoestrus cows cycling or to synchronise cows. Alternatively, injection programmes using other hormones can be used in place of CIDRs.

- A few cows are given hormone treatment for “super ovulation” (getting the cow to shed many eggs at ovulation, rather than just one). This is not common but is used in embryo transfer programmes to generate many offspring from one cow.

Embryo transfer

Embryo transfer (ET) is a more complex procedure than AI and can be used in cattle and deer. Its benefits are not likely to be seen as quickly as those of AI. It has been used commercially to bring in genetic material from overseas, and to transfer embryos from elite doner animals to recipients with less genetic merit.

ET involves the synchronization of oestrus as above, and superovulation of females (giving them the follicle- stimulating hormone FSH) to cause several ova to be released at oestrus. Once fertilised the ova are removed surgically 6 to 7 days after mating and the embryos can be stored frozen. They are transferred to hormonally prepared recipient animals by laparoscopy and results are generally fairly good.

Reproductive Interventions - Deer

AI has also been successfully used as a tool for breeding hinds as much as 6 weeks earlier than usual, through synchronising oestrus cycles of the hinds and using a melatonin-treated vasectomised stag to show which hinds remain in heat.

Semen is collected from stags by electroejaculation or use of an artificial vagina and stored frozen in straws until required. The hinds to be inseminated are usually treated with hormones in intravaginal pessaries to ensure that they are in oestrus when required, and it is usually convenient to synchronise the oestrus of several hinds so that they can all be inseminated at the same time.

Semen collection

For semen collection, either electro-ejaculation or an artificial vagina can be used, although the first is more common. The semen can be frozen in straws for later use and this has been successful in red deer and wapiti.

An artificial vagina is usually used with a dummy hind but a high proportion of ejaculates collected this way contain viscous fluid that contains relatively few sperm.

When semen is collected by electroejaculation, the stags must be anaesthetized, or adequately sedated by a veterinarian, and the procedure is usually straight-forward when carried out by a skilled technician. It involves use of a rectal probe that emits electrical pulses to stimulate ejaculation, which occurs quite quickly. Some stags do not give good quality semen sample whereas others do.

It's very important that the stags selected for semen collection are handled carefully and are familiar with the yards and facilities to avoid unnecessary stress.

Synchronisation of oestrus in hinds

Selection of hinds for AI should take place as early as possible. To reduce stress on the hinds and their fawns, they should be fully weaned before synchronisation. Weaning before mating also helps ensure that the hinds are in good body condition to maximize conception rates.

Yearling or maiden hinds are not generally recommended as ideal recipients for cervical AI programmes. Hinds that have weaned a fawn in the previous season are more suitable.

The method most commonly used requires a progesterone-impregnated Controlled Internal Drug Release device (CIDR) to be carefully inserted in the anterior vagina for 12 days in red hinds or 14 days in wapiti hinds. A small dose of PMSG can be given when the CIDR is removed. This induces oestrus in most hinds.

The procedure is carried out by an AI technician and veterinarian and it is important to heed their advice and stick strictly to the synchronisation timetable.

It is helpful to expose the hinds to an active rutting teaser (vasectomised) stag for between 5 and 12 days

before CIDRs are put in.
This allows the hinds to have at least one natural heat before they are synchronised.

Insemination

Inseminations in red deer and wapiti can be carried out by a technician using techniques like those in the cattle industry, i.e. the semen sample is deposited from a pipette in the vagina through the cervix into the uterus, and the technician uses an arm in the rectum to help guide the pipette through the cervix.

For red deer, most programmes involve a single insemination using a laparoscope to help the operator put the semen dose into the horns of the uterus

Following insemination, hinds should be run separately from entire stags for at least 14 days and then a chaser stag introduced. Each chaser sire should have no more than 30 AI hinds to serve.

Reproductive Interventions – Sheep

AI and ET can be used on stud sheep farms, but due to the high cost involved is not routinely used on commercial sheep farms.

CIDRs

These can also be used on sheep. The progestogen hormone impregnated sponges are inserted into the ewe's vagina. Progesterone suppresses oestrus and ovulation in cycling ewes. Once the CIDR is removed (after 12–14 days) there is a fall in progesterone level and a predictable oestrus and ovulation occurs. Typically a ewe shows oestrus within three days of CIDR withdrawal when used within the breeding season. Any ewes not fertilised at the first oestrus after CIDR removal will return to service 17 days later and remain generally synchronised.

Fecundity vaccines

Fecundity vaccines such as Androvax and Ovastim are be used to increase the rate of multiple births by increasing ovulation rate in treated ewes. Lambing is typically increased by around 20%. They stimulate antibodies in the ewe which create a change in hormonal balance and alters the function of the ovaries, increasing the number of eggs shed.
These are only used in sheep as other species normally only have a single offspring per breeding.

Reproductive Interventions such as synchronisation of oestrus, electro-ejaculation, artificial insemination and embryo recovery and transfer must only be carried out by or under the supervision of a veterinarian. Only veterinarians can prescribe and supervise the use of Prescription Animal Remedies (PARs) and Prescription Veterinary Medicines (PVMs). The sedatives and recovery agents used for these procedures are PARs or PVMs.

Glossary

Anoestrus: Failure to come into oestrus (heat). All cows have a period of anoestrus after calving but it can also be caused by disease or abnormality. Slow return to oestrus can be a major problem in New Zealand dairy herds.

Antibiotic: Formulations or products which inhibit the growth of or kill micro-organisms.

Antibodies: Proteins formed by the lymphatic system in response to foreign organisms to de-activate or kill them.

Artificial breeding (AB): A range of procedures involving human intervention in breeding. Includes AI, or artificial insemination; ET, or embryo (fertilised egg) transfer; MOET (multiple ovulation embryo transfer).

Artificial insemination (AI): Technique for putting semen in the cow without mating with a bull; technician places semen by pipette into cows in oestrus

Bobby calf: A milk-fed calf over four days of age that is sent for slaughter.

Breeding season: The time of the year when animals will naturally mate. Cattle are not seasonal and non-pregnant cows cycle continuously throughout the year assuming good health.

Breeding value: A calculation of the effect of measured genetic traits. EBV = estimated breeding value.

Calf: Young cattle of either sex with temporary ('milk') teeth. Some farmers call them weaners once weaned; others refer to animals up to one year old as calves.

Calving spread: Time from the birth of the first calf to the birth of the last calf for the herd.

Cervix: 'Neck' of the uterus, which helps protect against infection and expands for the calf to pass through during birth.

Colostrum: The first milk produced by a cow after birth, supplying a high level of antibodies and immune factors that give the newly born calf resistance against infectious agents. Cow colostrum looks yellow and is high in vitamin A, fat and protein.

Conception rate: Percentage of cows mated that conceive.

Contagious: A disease that is passed between animals.

Cowper's glands: Pair of glands alongside the urethra of bulls that supply fluid to neutralise and cleanse the urethra before semen passes through at ejaculation.

Cryptorchid: A male animal rendered infertile by having the testes remain in the abdomen. This may occur naturally or can be done by farmers (not used in cattle).

DNA (deoxyribonucleic acid): The substance that conveys genetic information, found in the chromosomes in the nucleus of all cells.

Dystocia: Difficulty in giving birth.

Electro-ejaculation: Using a mild electric shock delivered by rectal probe to stimulate the male to ejaculate; used to collect semen for AI or for inspection.

Embryo: Term given to the fertilised ovum implanted in the uterus in early pregnancy.

Epididymis: Tube structure attached to the testes, where sperm collect and mature before ejaculation.

Exotic breeds: More recently introduced cattle breeds, usually from Europe – e.g., Charolais, Simmental and Limousin.

Fallopian tube: See 'oviduct'.

Fecundity: The ability to have a large number of offspring.

Fertilisation: The fusion of sperm and egg.

Fertility: The ability to reproduce.

Foetus: Term given to the growing calf within the uterus.

Follicles: Hollow vesicles on the ovaries, each containing one egg (ovum).

Forward store: Stock in good condition, almost ready for slaughter but not yet at maximum weight or carrying quite enough fat cover.

Genetics: The science of breeding and inheritance, usually involving analysis of and selection for production traits (e.g., lean growth or high milk protein).

Gestation time: The time from conception to birth; averages around 282 days for cattle (range 270–290 days).

Gonad: An organ (testis or ovary) that produces gametes (spermatozoa/sperm or ova/eggs)

Heifer: Young female cattle with no more than six permanent incisors. Farmers often use this term for females until they have reared their first calf, whether they calve at 2 or 3 years old.

Heritability: The percentage of variation in a trait caused by genetics; the remainder of the trait's variation is caused by environment. For example, heritability of 0.4 or 40% means 40% of the differences between animals come from genetics, 60% from environment (e.g., animal health, feeding or management).

Heterosis (hybrid vigour): The genetic advantage gained from crossing animals from two or more unrelated breeds.

Hormone: Special chemical secreted by the body to signal body function changes.

Implantation: The process in which the fertilised egg attaches to the lining of the uterus at the beginning of pregnancy.

In-calf rate: Percentage of cows mated that test in-calf at pregnancy testing or scanning.

Induction: Hormonal treatment to make a cow give birth earlier than full term; used in the past in dairy farming to shorten gestation and increase the cow's days in milk for the following lactation. Routine induction of calving is no longer allowed in NZ.

Infertility: The inability to reproduce.

Libido: Sex drive – i.e., interest in mating. In bulls it is measured by the willingness to mount and serve within a given time.

Marking: The beef industry term used for ear-marking, tagging, castrating and recording.

Mating: When cows in 'heat' (oestrus) are served by a bull or artificially inseminated.

Non-return rate: Percentage of mated cows that do not return to oestrus after mating.

Nurse cow: A cow that feeds extra calves as well as her own.

Oestrous cycle: Cow's reproductive cycle from one oestrus to the next; averages 21 days.

Oestrus: The period of time when the cow is receptive to the bull.

Ovary: Female organ that releases eggs and female hormones (oestrogen and progesterone). The cow has two.

Oviduct: The tube that takes the egg from the ovary to the uterus. Fertilisation usually occurs in the oviduct (also known as Fallopian tube).

Ovulation: The release of the egg from the mature follicle on the ovary.

Ovum: Technical term for the egg released from the ovary. Plural = ova.

Oxytocin: A hormone produced by the pituitary gland, responsible for starting labour by causing the uterus to start contractions. Oxytocin also causes milk letdown in response to stimuli such as calf suckling or milking procedures.

Parturition: The birth process.

Penis: Male organ used for urination and to deposit semen in the cow's vagina at mating.

Pituitary gland A small hormone-secreting gland attached to the base of the brain.

Pregnancy testing: Testing to detect pregnancy; may be done manually (by feel through the rectum) or using ultrasound scanning.

Prime: An animal that is in optimum condition for slaughter.

Prostate gland: Gland that opens into the urethra and supplies a small amount of fluid for semen.

Scrotum: The sac that contains and protects the testes. Contraction and relaxation of the scrotum controls the temperature of the testes to keep the sperm viable.

Semen: The combination of sperm and fluids ejaculated by the bull.

Seminal vesicles: Glands that produce most of the nutritive fluid in semen that sustains the sperm.

Silent heat: Heat where the cow shows no outward signs of oestrus but ovulates. Bulls can detect cows in silent heat by smell.

Sperm: The male reproductive cell that penetrates the egg at fertilisation. Carries genetic material from the bull to make pairs of chromosomes with the genetic material from the cow (contained in the egg).

Spermatic cord: Consists of nerve, blood vessels and sperm duct (vas deferens). Its main task is to carry the sperm from the epididymis to the seminal vesicles.

Steer: Castrated male cattle beast. It does not develop secondary sexual characteristics (e.g., large heavy shoulders) or a masculine temperament.

Submission rate: Percentage of cows available for mating that are mated or submitted for AI in a given period.

Teaser bull: Vasectomised male cattle beast used to encourage cows to show oestrus and to identify cows in oestrus (especially if fitted with a chin ball harness). Vasectomised bulls retain secondary sexual characteristics – muscling, sex drive, aggression and other ‘bull’ characteristics.

Terminal sire: A bull whose progeny will be slaughtered for meat rather than being used for further breeding.

Testes (testicles): The male reproductive organs that produce sperm and the male hormone testosterone. The bull has two. Singular = testis.

Urethra: The tube that carries semen and urine to the exterior of the body.

Uterus: The female organ where the calf grows from implantation until birth.

Vagina: Tube connecting the cow’s uterus with the external genitals, where semen is deposited in mating and calf passes out during birth.

Vas deferens: The tube that carries sperm from the epididymis to the urethra for ejaculation.

Vulva: Cow’s external genitals that protect the entrance to the vagina.

Weaner: An animal making the transition from being suckled to an all grass diet, usually at about 6 to 8 months old for beef calves.

Yearling: A cattle beast of about a year old.

Further Reading

The following websites and books might be interesting for those who want to learn more about reproduction.

Websites

Animal Health Board for information about New Zealand's bovine tuberculosis control regime and farmers' legal requirements –https://ospri.co.nz/

AsureQuality NZ Ltd for information about disease testing, including BVD, EBL and bovine Tb – www.asurequality.co.nz

Beef + Lamb New Zealand (was Meat and Wool New Zealand) for information and fact sheets (look for R&D Briefs) about beef cattle reproduction and management and sheep production – www.beeflambnz.com

Beef New Zealand for research and technical information about beef cattle production in New Zealand – www.beef.org.nz

DairyNZ for technical information and fact sheets about dairy cattle production in New Zealand – www.dairynz.co.nz

The NZ Deer Industry for research and technical information about deer farming - https://www.deernz.org/

Books and Publications

Beef Cattle Reproduction, 1984 – proceedings of an Animal Industries Workshop at Lincoln College, edited by G. K. Barrell. This book is getting old but most aspects of beef reproduction discussed remain important today.

Bull Selection, 2012, produced by Beef + Lamb New Zealand. Provides good information about bull soundness and the use of EBVs to select bulls for different purposes (e.g., calving ease). Available online at http://www.beeflambnz.com/Documents/Farm/Bull%20selection.pdf

Profitable Farming of Beef Cows, 2009, edited by Steve Morris and Duncan Smeaton and published by Meat and Wool NZ, Beef Council. This book discusses most aspects of beef cow management including reproductive performance. Available online at http://www.beeflambnz.com/Documents/Farm/Profitable%20farming%20of%20beef%20cows.pdf

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Test Yourself Answers

Test Yourself #1

1. Connect the male reproductive structure in list A with its function in list B.

A	***B***
scrotum	*controls temperature of the testes*
testes	*produce sperm and testosterone*
epididymis	*where sperm are stored and mature*
vas deferens	*transport sperm from testes to urethra*
seminal vesicles	*produce nutritive fluid in semen*
urethra	*tube for semen and urine*
penis	*deposits semen at mating*

2. List at least four secondary sex characteristics caused by testosterone.
   Any four of: aggression, digging, head rubbing, pushing against objects, snorting, bellowing or mumbling, fighting, territorial behaviour, sex drive and mounting behaviour, large body size, heavy bone, muscling, high appetite and fast growth rate, low fat levels, bull shape with heavily developed shoulders and crest of the neck.

3. Briefly explain the following words:
   a) Castration = rendering a male sterile by removal of the testes
   b) Vasectomy = rendering a male infertile by removing a section of the vas deferens so that sperm cannot be ejaculated

4. Why are some bulls vasectomised?
   Surgical castration: done by cutting the scrotum and removing the testes. Can be performed on bulls of any age but they will need appropriate pain relief and possibly a sedative.
   To encourage cows to come into heat, detect cows in silent heat and/or assist with oestrus detection – e.g., if fitted with a chin ball harness.

Test Yourself #2

Connect the female reproductive structure in list A with its function in list B.

A	***B***
ovaries	*produce eggs and hormones*
oviduct	*where fertilisation occurs*
uterus	*where the embryo develops*
cervix	*protects developing calf from infection*
vagina	*where the sperm is deposited during natural mating*
vulva	*external vaginal opening*

Connect the female hormone in list A with the description in list B.

A	***B***
oestrogen	*made in large amounts by the mature follicle, surges before ovulation, makes the cow show oestrus*
progesterone	*made by the corpus luteum after ovulation, prepares the uterus and maintains pregnancy, stops the cow from cycling again*
prostaglandin	*made by the non-pregnant uterus, kills the corpus luteum so that the cow can cycle again*
oxytocin	*made by the pituitary gland, makes the uterus contract and causes milk letdown*
follicle stimulating hormone	*made by the pituitary gland, stimulates follicles on the ovary to develop*

True or false?

a. Anoestrus is the period when the cow is ready for reproduction. *F*

b. Oestrus is when the cow is ready to mate. *T*

c. Eggs are produced inside individual follicles on the ovaries. *T* *d.* Once the egg is fertilised the production of progesterone stops. *F*

e. Fertilisation occurs in the oviduct. *T*

f. The pregnancy length is also known as the gestation period. *T*

g. The foetus gets nutrients and oxygen via the placenta. *T*

h. Ovulation occurs during oestrus. *F*

i. Cows are seasonal breeders and only show oestrus in spring. *F*

j. Heifers always reach puberty at 9–11 months old. *F*

k. Puberty is affected by liveweight so well grown heifers reach puberty earlier than smaller ones of the same breed. *T*

l. Some cows show no signs of oestrus but ovulate anyway. *T*

Test Yourself #3

1. Describe the use of tail paint for heat detection.
   Paint on back bone immediately above the tail in a strip about 60 mm wide and 150 mm long, rubs off when cow is ridden by other cows or bulls. New colour usually applied once cows are mated or inseminated to differentiate cows that do not cycle again and cows that return to oestrus. Special products are best because some paints don't last or don't clearly show rubbing.

2. Describe the use of a ram harness for heat detection.
   The harness with its crayon block on the ram's brisket marks the rump of ewes when the ram mounts, indicating when they are mated and whether ewes return to oestrus, i.e. they fail to conceive from the previous mating. This information is mainly used for feed planning in late pregnancy and at lambing time.

3. Briefly describe two other heat detection aids.
   Any two of: ink bubble indicator = capsule that bursts under pressure of riding bull/cow; scratch pad indicator = shiny top that scratches off under riding behaviour; pedometer/activity meter shows greater walking and activity that indicates oestrus; teaser bull = rides cows in oestrus (including silent heats); chin ball harness on teaser or bull marks back of cow when he rides.

4. Why does it matter if a cow in oestrus is missed when drafting for AI?
   Calves 21 days later, 21 days less in milk or 21 day younger calf at weaning, may miss out on AI on dairy farm (so no chance of replacement heifer from her) and calve to beef bull, will be later every year because hard to make her earlier in future.

5. How can we tell if a bull has a semen quality problem?
   Might notice cows returning to oestrus or high rate of empties if single sire mated. Can have bulls physically checked before mating and/or have the vet check a semen sample.

6. What is the 'true' conception rate?
   Percentage of cows tested pregnant from the entire herd mated.

Test Yourself #4

1. Work out the expected calving date for cows mated on the following dates.

a) 13/10

+9/-3

= 22/7

= 22nd July

b) 28/11

+9/-3

= 37/8 – take off the 31 days of August to make this a date in September

= 6th September

4. Work out the expected fawning date for deer mated on the following dates.
   a) 13th March (Mated) 1st November (due)

   a) 28th March (Mated) 16th November (due)

5. Work out the expected lambing date for sheep mated on the following dates.
   a) 13th March(Mated) 10th August(due)

   b) 28th March(Mated) 25th August(due)

Expected due dates (being out by one day is OK).

Figure 11 This New Zealand Jersey cow has an activity meter and electronic identification for automatic drafting