ARTIFICIAL BREEDING OF BEEF CATTLE
IN THE NORTHERN TERRITORY

A MANUAL

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SUSTAINABLE AGRICULTURE

THE DEPARTMENT OF PRIMARY INDUSTRY AND FISHERIES IS COMMITTED TO THE PRINCIPLES AND PRACTICES OF SUSTAINABLE AGRICULTURE

Definition:

Sustainable agriculture is the use of practices and systems which maintain or enhance:

- the economic viability of agricultural production;
- the natural resource base; and
- other ecosystems which are influenced by agricultural activities.

Principles:

1. Agricultural productivity is sustained or enhanced over the long term.
2. Adverse impacts on the natural resource base of agricultural and associated ecosystems are ameliorated, minimised or avoided.
3. Harmful residues resulting from the use of chemicals for agriculture are minimised.
4. The nett social benefit (in both dollar and non-dollar terms) derived from agriculture is maximised.
5. Agricultural systems are sufficiently flexible to manage risks associated with the vagaries of climate and markets.

SUSTAINABLE AGRICULTURE IN THE NORTHERN TERRITORY
ARTIFICIAL BREEDING OF BEEF CATTLE
IN THE NORTHERN TERRITORY

A MANUAL

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INTRODUCTION

Ever increasing costs of production in the beef industry indicate a need to create an awareness of additional management practices available to the producer. Artificial Insemination is one practice which can be used in the Northern Territory for herd improvement in specific areas. This text aims to present a comprehensive account of Artificial Insemination techniques and to describe associated management practices.

A brief account of the anatomical and physiological aspects of the bovine reproductive systems is included. To gain an appreciation of the techniques of artificial insemination it is necessary to have an understanding of the structure and function of the various reproductive organs. In order to obtain a Northern Territory Artificial Breeding License a detailed knowledge of reproduction is required in accordance with the stipulations of the Northern Territory Breeding Act, 1979.

Artificial Breeding employs the art of Artificial Insemination (AI) which is the physical act of injecting semen into the female reproductive system, thus enabling conception to occur. It is a means of facilitating the union of the ova and sperm without physical contact between the cow and the bull.

The technique of Artificial Insemination has been reported to have been used as far back as the 14th Century by an Arabian horse breeder. However, the first recorded successful use of artificial breeding in cattle was the work of a Russian experimentalist early this century. In 1937, Danish veterinarians first introduced the presently used 'recto-vaginal' technique. Some 14 years later British scientists were able to show that semen could be stored indefinitely as deep frozen semen at -79°C. The first work in AI in Australia came at the end of World War II.

AI was first introduced into the Northern Territory in the 1950's. In January 1954, a number of Jersey cows were inseminated in Alice Springs. Insemination of a small number of Australian Illawarra Shorthorn cattle in Darwin was proposed for July 1956. Results of these inseminations are unknown.

Since these early attempts the greatest changes have been in the number of cows included in each insemination programme, the use of liquid nitrogen rather than dry ice and oestrus synchronisation.

Before becoming deeply involved in the theory and practise of AI, one must appreciate that cows are individuals and therefore biological entities. There may be considerable variation between animals because of genetic differences.

ADVANTAGES AND DISADVANTAGES

The development of successful artificial breeding techniques has been one of the outstanding advances in animal production this century. For a beef cattle breeder in arid or semi-arid regions the advantages and disadvantages must be considered carefully before a programme is commenced to avoid significant economic losses.

The major advantages and disadvantages associated with the technique as a management tool are as follows.
ADVANTAGES

1. Facilitates rapid genetic improvement.
2. Access to new blood lines.
3. Cross breeding can occur without capital outlay on new bulls.
4. Allows extended use of superior sires.
5. Allows access to sires which would otherwise be outside the normal price range of a commercial producer.
6. Planned properly, AI can provide a cheap source of good replacement bulls.
7. Control of reproductive disease in the nucleus herd.
8. Insurance against injury to a valuable bull.
9. Improves cattle husbandry as stock are regularly handled.
10. Less management difficulty with bulls between mating seasons.

DISADVANTAGES

1. Cost: An additional labour component of at least two (2) men for two (2) weeks will be required to conduct an effective programme. This, together with other factors detailed below, will raise the average calf production cost.
2. Knowledge of the breeding ability of the females included in the nucleus herd is required.
3. Conception rates will usually not be any higher than in normal mating situations. If the inseminator is inexperienced, conception rates will probably be much lower.
4. If unlicensed semen is used then it is possible that defective characters may not be detected for some time thus retarding real genetic progress in the herd.
5. Occasionally, even experienced inseminators encounter low conception rates in the Northern Territory where environmental conditions are often adverse and temperamental females make up a large proportion of the nucleus herd.
6. Good holding paddocks and yards with race and crush are essential. Holding paddocks should be close to the yards and be large enough and have sufficient feed to hold the animals. Otherwise mustering time becomes excessive.
7. Planning and organisation of AI programmes is essential. 'She'll be right, mate' is not a rule that applies in AI.
8. Adverse environmental conditions can cause disastrous results.
9. Cost of resources for detecting cows on heat, eg chin ball harness.
ANATOMY OF THE BULL'S REPRODUCTIVE TRACT

Anatomical terms used in this text may at first appear to be a foreign language. By using the correct terms to describe various structures they will soon become familiar.

The bull, unlike the cow, is equipped with gonads or primary sex organs outside the abdominal wall. The testicles are suspended in a sac, the SCROTUM. From the testicles, spermatozoa enter the secondary sex organs where they are mixed with secretions from the accessory sex organs, grow to maturity and are finally ejaculated.

The anatomical structures discussed can be seen in Diagrams 1 and 2.

Diagram 1: Sideview of the Male Reproductive Tract and Associated Organs.
Diagram 2: Detailed Diagram of Scrotum and Testicles.

TESTICLES

The paired testicles have two major functions:

a) to produce SPERMATOZOA,
b) to produce the male sex hormone TESTOSTERONE.

The testicles in a normal mature bull are oval in shape, 100 mm to 120 mm long and 60 mm to 70 mm in diameter. The scrotal circumference which includes both testicles and scrotum at the widest point should measure between 30 cm and 48 cm in a mature bull.

Bos Taurus bulls (Hereford, Shorthorn) tend to have short, thick testicles, whereas Bos Indicus (Brahman, Santa Gertrudis) have comparatively long slender testicles.

For high fertility the minimum scrotal circumference at 2 years of age for Bos Taurus bulls is 32 cm and 28 cm for Bos Indicus.
The body of the testicle as shown in Diagram 2 is parenchyma tissue which is made up of:

a) SEMENIFEROUS TUBULES in which spermatozoa are produced,
b) LEYDIG CELLS which produce the male hormone, testosterone,
c) SERTOLI CELLS which produce the hormone, oestrogen.

Plate 1: Cross Section of Testicular Tissue Showing:
   a) Semeniferous Tubules
   b) Leydig Cells
   c) Sertoli Cells
   d) Spermatozoa

The MEDIASTINUM TESTES is a fibrous sheet of tissue which extends two thirds of the way down the centre of the testicle. Spermatozoa migrate from the semeniferous tubules to the mediastinum testes which is the common drainage system to the head of the epididymis. Each testicle is separated in the scrotum (sac) by the MEDIAN SEPTUM.

SECONDARY SEX ORGANS

Epididymis

From the top of the testicle spermatozoa move into the HEAD OF THE EPIDIDYMIS, down the BODY OF THE EPIDIDYMIS, to the TAIL OF THE EPIDIDYMIS. They then ascend through the VAS DEFERENS and finally into the urethra. Spermatozoa are stored and mature in the epididymis.

Vas Deferens

The VAS DEFERENS, a long thin tube and the PAMPINIFORM PLEXUS are enclosed by the EXTERNAL CREMASTER MUSCLE until they reach the INGUINAL CANAL or entrance to the abdomen. The Vas Deferens, pampiniform plexus, (an artery and vein complex) and nerves associated with the testicle come together in the SPERMATIC CHORD which is the solid neck of the sac holding the testicle in the scrotum. There are two inguinal canals, one for each
spermatic chord where it enters the abdomen. Immediately prior to entering the urethra, the vas deferens becomes enlarged to form the AMPULLA. The tail of the epididymis and the ampulla are similar in that they both store maturing spermatozoa.

Urethra

The urethra is a dual purpose organ which acts as a passage for both urine from the bladder and the seminal fluids. Unlike the urethra in the cow, the urethra in the bull may be up to a metre long which is slightly longer than the penis.

Penis

This is the male injection unit. In the bull it remains in a 's' shape in the relaxed position and extends to straight upon stimulation. The 'root' or base of the penis is found between the pin bones. From there it extends forward, bending downwards in the 's' shape between the two inguinal canals, through the prepuce forming a tabular sheath. The body of the penis constitutes the major 's' shape portion or SIGMOID FLEXURE which is held in the relaxed position by the RETRACTOR PENIS MUSCLE. The BULBO CAVERNOSIS MUSCLE is attached to the root of the penis and enhances erection in males of most species. However, in the bull, erection occurs mainly through straightening of the sigmoid flexure, ie relaxation of the retractor penis muscle, and to a lesser extent by engorgement with blood. The GLANS PENIS is the free protrusive sensitive end of the penis which contains external urethral orifice and plays a major role in the sensual response during copulation. The PREPUCE forms a sheath over the penis and is suspended from the abdominal wall by two muscles. It is these muscles that determine whether the prepuce and the penis are held close to the abdomen or hang rather loosely — a common undesirable trait.

ACCESSORY SEX GLANDS

The three paired glands which secrete a clear fluid into the urethra near the point of entry of the vas deferens are:

a) Seminal vesicles,
b) Prostate gland,
c) Bulbo urethral gland.

It is the secretions of SEMINAL FLUID from these glands which combine with spermatozoa to form SEMEN. The seminal fluid has a number of functions. It cleanses the urethra prior to the passage of spermatozoa, provides a nutrient for the spermatozoa and provides fluid or physical volume to enhance the activity of spermatozoa. The volume of semen at each collection varies mainly as a result of the amount of seminal fluid excreted during ejaculation. The number of spermatozoa per ejaculate is in the order of 5 000 million and total volume varies between 4 and 20 ml.

SPERMATOZOA

Spermatozoa or mature sperm cells, carry the male animal's genetic characteristics and resemble 'tadpoles' under the microscope. The HEAD is pear-like in shape, attached to a MID PIECE and a relatively long TAIL. The tail is responsible for the wave like swimming motion observed under the microscope. The head which has an ACROSOMAL CAP on its foremost part, is responsible for penetration and fertilization of the female ova. Spermatozoa can be placed in a particular stain to identify live and dead cells as well as the morphology of the cells as seen in Plate 2.
ANATOMY OF THE COW'S REPRODUCTIVE TRACT

The internal female reproductive organs hang ventral to or below the rectum in the pelvic cavity in heifers and non-pregnant cows. With increased age of the cow and number of calvings the more CRANIAL parts tend to fall forward and over the brim of the pelvis. The rectum is the last section of the digestive tract and terminates at the anus.

Diagram 3: Sideview of Female Reproductive Tract and Associated Organs
The reproductive system of the cow from the rear or tail end (CAUDAL) to the head (CRANIAL) can be simply described using the following terms and Diagrams 3 and 4.

a) **VULVA**
b) **VAGINA**
c) **CERVIX**
d) **UTERUS — body**
   — horns
e) **FALLOPIAN TUBES or OVIDUCTS**
f) **INFUNDIBULUM or BASKET**
g) **OVARY**

Each of the organs illustrated in Diagrams 3 and 4 has a specific function. A knowledge of the structure and function of these organs is necessary before artificial breeding techniques can be used effectively. A brief description of the important reproductive organs is given below.

*Diagram 4: Plan of the Female Reproductive Tract*
OVARIES (GONADS)

There are two ovaries suspended in the MESOVARIAN LIGAMENT on either side of the midline and connected to the remainder of the reproductive tract by the fallopian tube. The mesovarian ligament is that part of the BROARD LIGAMENT which hangs from the roof of the abdominal cavity and attached caudally to the kidney. The ovaries are partially enclosed by the INFUNDIBULUM or basket.

Ovaries vary in shape and size but generally they are oval and approximately 30 mm x 25 mm x 12 mm thick (1.2" x 1" x 0.5").

Structures which may be found on the ovary are illustrated in Diagram 5 and include:

1. GRAAFIAN FOLLICLES: Blister like structures on the ovarian surface containing the ovum or egg. They may be classified as primary or immature follicles, secondary and tertiary or mature follicles.

2. CORPUS HAEMORRHAGICUM: When the graafian follicle ruptures the remaining cavity fills with blood to form the corpus haemorrhagicum.

3. CORPUS LUTEUM: This structure is commonly known as the 'yellow body' and consists of luteal cells.

4. CORPUS ALBICANS: When the Corpus Luteum of pregnancy regresses (dies back) the white scar tissue formed is called the Corpus Albicans.

Presence of these structures assists in the clarification of the stage of ovarian development. Their functions are described in a later section.

The main functions of the ovaries are:

a) production of OVA (eggs),
b) production of the female sex hormones.

The ovarian or sex hormones have a regulatory function in the body. The ova contains female genetic material and when fertilized progressively develops into an embryo, foetus and finally a calf is born.

Diagram 5: Ovarian Development in the Cow
INFUNDIBULUM

This is the funnel shaped structure found in association with the ovary and is suspended in the MESOVARIAN LIGAMENT. It catches the ova as it is shed from the ovary and channels it into the FALLOPIAN TUBE hence the common name ‘basket’ is often used.

FALLOPIAN TUBE (OVIDUCT)

The fallopian tube is a thick walled, narrow tube which is approximately 3 mm in diameter and 150 mm in length. It is suspended in the BROARD LIGAMENT and connects INFUNDIBULUM to the UTERUS.

UTERUS-HORNS

There are two uterine horns in the cow. Together with the BODY of the uterus they form a ‘Y’ shaped organ and join caudally to form the body of the uterus. They vary from 150-300 mm in length and 10-35 mm in diameter in the non pregnant cow. The horns are suspended in the broad ligament from the roof of the abdominal and pelvic cavities and appear to have a semi circular shape.

UTERUS-BODY

The BODY of the uterus is that portion of the uterus common to both horns. It varies in length from 25-50 mm. At the bifurcation of the body of the uterus the horns are connected by the INTERCORNUATE LIGAMENT. This makes the uterus appear to be longer than it actually is. At the caudal end the uterus merges with a hard muscular organ called the CERVIX.

During pregnancy, the uterus develops and enlarges to provide an aqueous environment and life support system for the calf prior to birth.

CERVIX

The CERVIX can best be described as a firm muscular organ. There is often variation in size and shape of the cervix from animal to animal. It varies from 50-100 mm in length and 15-60 mm in diameter and contains 3-5 transverse annular folds.

There is a narrow spiral like canal running through the centre called the CERVICAL CANAL. This canal enlarges slightly when the animal is on heat and enlarges greatly during the birth process to allow the passage of the calf. The caudal opening of the cervix into the VAGINA is known as the ‘OS CERVIX’. During pregnancy a mucus plug blocks the cervix to prevent entry of potentially dangerous organisms to the uterus.

VAGINA

Where the cervix extends caudally into the vagina it forms a blind annular sac called the FORNIX VAGINAE.

The SUB-URETHRAL DIVERTICULUM (blind sac) is found cranial to the opening of the urethra, which is approximately 100 mm forward of the caudal vaginal opening. Both enter the vagina on the ventral surface. Occasionally a transverse fold of membrane is found cranially to the urethral opening. This is the HYMEN and is usually only found in heifers.

The CLITORIS is a small erect fibrous organ on the floor of the vagina and is the female equivalent to the penis.
The FORNIX VAGINAE, SUB-URETHRAL DIVERTICULUM, URETHRAL OPENING and VAGINAL FOLDS may all be obstacles during artificial insemination.

VULVA

The VULVA forms the external opening to the vagina. It has two lips or LABIA which are made up of strong constrictor muscles. These muscles are capable of closing the vulva to form a seal from the external environment.

PHYSIOLOGY OF REPRODUCTION IN THE COW

Reproductive development in the cow is characterised by a sequence of physiological events. Puberty in respect of the female is that stage of development when ovulation or oestrus first occurs. After puberty is reached the oestrus cycle begins and may be followed by mating, fertilization, pregnancy and calving. Age and size at puberty vary depending on nutrition and environmental factors. It has been shown that puberty is more closely related to body weight than age.

OESTRUS CYCLE

The oestrus cycle is best described using a pie chart as in Figure 1. This pie chart also shows the various structures found on the active ovary during the cow's oestral cycle. Cycle length varies between 18 and 24 days with an average length of 21 days. Factors affecting cycle length include age, nutrition, disease, individual differences and human intervention. The oestrus cycle can be divided into four phases:

1. Oestrus  
2. Metoestrus  
3. Dioestrus  
4. Proestrus

![Pie Chart](image-url)
The stage of the cycle can be determined using:

a) hormone levels in the blood,
b) external behavioural characteristics,
c) rectal palpation of ovarian structures.

1. Oestrus

During oestrus, sexual receptivity is displayed by the signs of oestrus and the cow is referred to as being 'on heat'. The most reliable external sign is when the cow stands still while being mounted by another beast. On the ovary itself, a dominant Graafian Follicle matures to form a structure 12 to 15 mm in diameter. The cow's hormonal profile at this stage reveals high levels of oestrogen and in the later stages of oestrus, a rise in the level of luteinising hormone (LH) can be observed. The hormonal levels found in the cow at each stage of the oestrus cycle are represented in Figure 2.

![Graphic Representation of Blood Hormone Levels Throughout the Oestrus Cycle](image-url)
Oestrus lasts between 4 and 27 hours with 6-8 hours being the normal range for Bos Indicus or humped breeds and 10-14 hours for the Bos Taurus or British breeds. Heifers tend to have shorter ‘heat’ periods than mature cows. The influence of reproductive hormones on reproductive organs during this phase may be summarised as follows. The vulva is relaxed and slightly swollen, the vaginal wall is slightly inflamed and moist, the cervix is relaxed and there is a greatly increased secretion of clear silvery mucus which may be seen draining from the labia.

2. Metoestrus

The cow goes ‘off heat’ in response to changes in hormone levels. The most important change at this stage is a rise in the level of luteinising hormone which peaks immediately prior to the rupturing of the follicle. Ovulation occurs between 12 and 13 hours after the end of oestrus or 24 hours after the commencement of oestrus. The CORPUS LUTEUM is formed and begins to secrete progesterone approximately 3 days after ovulation.

The external signs of metoestrus are relatively insignificant when compared to those displayed at oestrus. Metoestrus lasts for 6-8 days. During the early part of this phase the mucus which was a thin, clear, shiny fluid during oestrus becomes opaque and viscous. The consistancy of this mucus is similar to that of egg white. Slight traces of blood may be observed. This occurs more frequently in heifers than older cows and is not an indication of whether the cow has or has not conceived.

3. Dioestrus

If the ova is not fertilized the next phase of the oestrus cycle, dioestrus, occurs. Dioestrus varies from 7-10 days in length. The corpus luteum is maintained until approximately day 17 of the cycle or the end of dioestrus. It then begins to decrease in size and regress. At the same time the concentration of progesterone in the blood rapidly decreases and oestrogen concentration rises. If fertilization had occurred the corpus luteum would not regress as it is required to produce the progesterone which is essential to maintain pregnancy. This source of progesterone is especially important during the first 5 months of pregnancy. For the remaining 4 months the placenta is capable of providing sufficient progesterone to maintain the pregnancy.

4. Proestrus

This phase lasts for 1-3 days. The corpus luteum continues to regress and a new follicle ripens for the forthcoming oestrus period. The concentration of oestrogen in the blood rises rapidly and is accompanied by a rise in LH levels. The cow becomes restless and searches for a bull. The mucus secretion again become clear and watery.

OVULATION

Unlike the bull which continually produces sperm cells the cow has a set number of potential ova at birth. As follicles mature ova are ovulated, one per oestral cycle in the normal mature cow. As one follicle assumes dominance, other growing follicles regress.

The cow is unique amongst farm animals in that it does not shed the egg or ova from the ovary until it has gone off heat. The average time from the onset of oestrus to ovulation is 24 hours. When the ova is shed, the cavity left by the burst follicle fills with blood. This blood clots and the body is called a CORPUS HAEMORRHAGICUM which subsequently develops into the yellow body or CORPUS LUTEUM. When the follicle ruptures the concentration of LH decreases and
the concentration of progesterone increases. Progesterone is the hormone produced by the luteal cells in the corpus luteum (yellow body) and is responsible for preparing the uterus for implantation and maintaining pregnancy.

**FERTILIZATION**

Spermatozoa live for varying periods of time once they are deposited in the female tract. The following table shows the length of time they may be expected to remain viable in the various sections of the tract.

<table>
<thead>
<tr>
<th>Section</th>
<th>Viable Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vagina</td>
<td>6-12 hrs</td>
</tr>
<tr>
<td>Cervix</td>
<td>36-48 hrs</td>
</tr>
<tr>
<td>Uterus</td>
<td>24 hrs</td>
</tr>
</tbody>
</table>

Sperm travel at a speed of approximately 3 mm per minute and move from the cervix to the site of fertilization. The movement of the spermatozoa is afforded not only by their swimming ability, but by the contractions of the lining of the uterus and the fallopian tube. Regardless of the speed of access to the ova, sperm require time in the tract to mature or gain the capacity to fertilize the ova. This is expected to take at least 1 hour but may take longer.

Once the ova is shed, it has a fertile life of about 6 hours. It takes 72 hours for the ova to reach the horn of the uterus therefore spermatozoa must be present in the upper third of the oviduct at an early stage to ensure that fertilization occurs. By the time the fertilized ovum (embryo) reaches the uterus it has developed to the 16-32 cell stage. During the period prior to the embryo reaching the uterus, intrauterine antibiotic treatment can be used without adversely affecting pregnancy.

When semen is deposited in the tract during an AI programme, the reproductive organs should be massaged to stimulate the release of the hormone oxytocin. Oxytocin is also released as a result of stimulation by the bull during service. This hormone is responsible for the active muscular contractions of the uterus and fallopian tubes. Rough handling of the female organs may cause the release of adrenalin which inhibits these contractions and therefore reduces the likelihood of conception.

When the embryo reaches the uterine horn the outer placental membranes form an attachment with the lining of the uterus (implantation). Once implantation has occurred the embryo is called a foetus. This usually occurs on or about day 10 of the pregnancy.

**DETECTION OF OESTRUS**

Successful artificial breeding is dependant upon the ability of the inseminator to determine if a cow is on heat or not. Heat detection is essential for the time of ovulation to be determined. As previously explained oestrus can be detected in cows by reference to the external signs of ‘heat’ which she displays. Under natural mating conditions, the cow will only allow the bull to mount and serve her during oestrus. Accurate detection of oestrus is the most important part of an AI programme. False heat detection is probably the major cause of poor conception rates in beef cattle.

Practical experience and experimentation indicate that the best time to observe cows for signs of heat is during the first two hours after daybreak and the last two hours before dusk. The
periods 0600 - 0800 and 1630 - 1830 are therefore usually the times when cows not on heat are grazing and active cows are showing strong signs of heat.

Figure 3: Oestrus Detection

SIGNS OF HEAT

When one considers the 'vegetative' existence the cow usually leads, changes which occur during oestrus, particularly those related to behaviour, are remarkable. Those who know their cows on an individual basis can often detect oestrus in a change in the animal's temperament. THE SURE SIGN that a cow is on heat is when she STANDS TO BE MOUNTED by another animal. See Figure 3.

An animal in proestrus often:

- a) becomes restless, walks and bellows excessively,
- b) shows less interest than normal in her calf,
- c) is aggressive toward other cows and actively searches for the bull,
- d) becomes very alert, ie ears 'pricked' and head raised.

Immediately prior to oestrus the cows with a common desire form what is described as an active group. This group separates from the remainder of the herd which appears to be disinterested in their activities and continue feeding normally. Cows in the active group mount one another and leave clues of their oestral conduct.

* Ruffled hair and bare, chaffed spots over the butt of the tail, pin bones and hips indicate that the cow has been ridden.

* Mud or ruffled hair on the flank areas is another indication that the cow may have been mounted.
• Clear transparent mucus may string from the vulva and cling to the tail or hindquarters — the ‘bulling string’.

• The vulva may be slightly swollen with the lining of the vulva and vagina showing signs of congestion and mucus secretion.

• Where calves are left with cows in an AI programme, they tend to follow the cows on heat. Young male calves will attempt to mount these cows. Managers should be aware that any bull calves with the cows should be sufficiently immature as not to be able to successfully mate with the cows.

• The temperature of a cow in oestrus may be elevated slightly above the normal temperature of 100.5°C to approximately 103°C for a brief period. This is of little practical value.

• Electronic devices can be used to measure vaginal mucus conductivity. This information allows the time of ovulation to be determined.

• Those people who have a cow that is milked regularly will notice that, when she is on heat, her milk production drops for that day. She may also become restless at milking time.

• Plasma progesterone may be measured from milk samples to plot the stage of the cows oestrous cycle. During the luteal phase of the cycle the progesterone levels are high but fall during oestrus.

Additional Aids for Heat Detection

Other aids available to assist with heat detection can be purchased commercially or obtained by employing a veterinary surgeon to surgically modify part of the bull’s reproductive system.

• Commercial products such as ‘Tailpaint’ by ICI and Kamar ‘Heat Mount Detectors’ are applied to the sacral region of the cows spine. Tailpaint is cracked by the riding action of another animal while the dye container of the heat mount detector is burst by the action.

• Chin balls may be fitted as halters to steers injected with testosterone. These chin balls are filled with marking fluid and are like an oversize biro which leaves ‘markings’ on the animal’s back in the area of the thoracic vertebrae. Correct fitting of a chin ball harness is illustrated in Plate 3.

• A portion of the vas deferens may be removed to produce a vasectomised bull.

• Sidewinders are entire males which have the prepuce and penis relocated to one side or exposed caudally between the animals back legs.

Each of these aids has disadvantages of some description. Markers may result in false identification of cows on heat due to the cow being mounted when she is not prepared to stand still. Chin balls may be good but experience in ‘reading’ the markings is essential. Marks placed over the loins or above the wither are indicative of the steer resting his lower jaw on the cow as he simulates intercourse. Other marks may be made during mounting, dismounting or as the cow runs from beneath him when he attempts to mount.

When males repeatedly have unsuccessful intercourse either as the result of diverted penis, vasectomy or castration, they tend to lose interest in their occupation and are thus rendered inactive and of little use. Moreover, when intromission does occur, there is the possibility of
transmitting an infection from one animal to another as the male rapidly accommodates each cow on heat. If males are used to identify cows on heat, it is suggested that they represent between 8% and 10% of the cow population.

OESTRUS SYNCHRONISATION

Oestrus synchronisation is the treatment of cows so that all animals in a treated group will display oestrus within a much shorter period than normal. The aim of synchronisation is to get as many cows as required to ovulate more or less within a given short period of time. Ultimately, the cows are then inseminated at a later time whether they are displaying overt oestrus signs or not.

Early attempts at synchronisation were aimed at prolonging the Luteal phase of the cycle. Recently, hormone like substances called prostaglandins (PGF₂⁺) have been used to shorten the luteal phase and synchronise the group’s oestrus period. Prostaglandins are not a fertility drug. The cows must be cycling normally and have an active corpus luteum for the drug to be effective. If the cow is in proestrus or oestrus then the prostaglandin will not have an effect and the cow will come on heat normally. If cows are to be synchronised they must be in the metoestrus or dioestrus phases. An active corpus luteum will regress when a cow is injected with the correct dose of prostaglandin. A new Graafian follicle develops and signs of heat are displayed in the following 48 to 96 hours. If PGF₂⁺ is administered to a random group of non-pregnant cycling cows it is probable that 75% will show signs of heat in the ensuing 4 days. If a cow is pregnant and PGF₂⁺ is administered, the likelihood of her aborting is very high, particularly during the first 5 months.

Prostaglandins are to be administered only by a registered veterinary surgeon or under the supervision of a veterinary surgeon.

There are two basic oestrus synchronisation programmes suggested for use under Northern Territory conditions when using PGF₂⁺ alone.
Programme A requires the cows to be watched for 5 days. Any cows not observed to be ‘on heat’ are injected with PGF$_2$α on the 5th day and are watched for heat during the following 4 days. In each instance, cows observed on heat are inseminated 12 hours later.

Programme B — all cows are injected with PGF$_2$α on day 1 and again on day 11. They are observed over the next 4 days and inseminated 12 hours after heat is first detected. These programmes are illustrated in Figure 4.

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**Figure 4: Suggested Oestrus Synchronisation Programmes.**

Progesterone releasing intravaginal devices (PRID’s) are another oestrus synchronisation device available. These maintain high levels of progesterone in the circulating blood. After the PRID is removed from the vagina, progesterone levels drop and oestrus follows.

As an alternative to the sole use of PGF$_2$α; Progesterone, PMSG (Pregnant mare serum gonadotrophin) and PGF$_2$α may be used in combination to provide a systematic approach to
modifying the cows hormonal levels and time of ovulation. A suggested synchronisation programme based on this combination suitable for the Northern Territory involves insertion of the PRID's in all cows on day 0. On day 6, inject all cows with PMSG and PGF$_2$α. Remove all PRID's on day 7 and inseminate the cows 56 hours after the PRID's are removed. This system removes the need for oestrus detection and is closely aligned with the ideals of ovulation synchronisation.

Removal of calves from cows for 1-2 days or 'shanghai-ing' has been used as an alternative method of oestrus synchronisation.

As drugs have no magical powers, cows are still influenced to a large extent by the environmental conditions prevailing at the time of the programme. It is possible that they may either not come on heat or may have a 'silent heat' (where there is an absence of external signs). Factors such as changes in the animals' diet may have adverse effects on the effectiveness of the oestrus synchronisation.

**TIMING OF INSEMINATION**

Information available on the length of time required from oestrus detection to insemination to achieve maximum fertility in beef cattle is inconclusive. However, research indicates that inseminations performed no earlier than 6 hours and no later than 24 hours after the onset of

![Graphic Representation of Expected Conception Rates Resulting from Various Insemination Times.](image)

Source: Artificial Breeding and Pregnancy Diagnosis in Beef Cattle (1973)
Br. Lloyd E. Donaldson, B.V.Sc., M.V.Sc., (Qld) Ph.D. (Cornell) M.A.C.V.S.

Figure 5: Graphic Representation of Expected Conception Rates Resulting from Various Insemination Times.
oestrus result in a maximum number of conceptions. Peak fertility seems to occur when inseminations are made during the middle and toward the end of oestrus. It is clear that in hot, humid climates the duration of behavioural oestrus in cattle is shorter than in cooler climates. Timing of insemination in breeds of Bos indicus origin is different to that recommended for British breeds. Experience under Northern Territory conditions indicates that Bos indicus should be inseminated at the time of heat detection for optimal fertility. This has been particularly obvious in Brahman heifers.

Generally speaking, inseminations should be carried out 12 hours after the initial detection of oestrus under extensive conditions. For example, cows detected on heat in the morning (0600-0800 hours) are inseminated that evening. Cows found to be on heat in the evening (1600-1800 hours) are inseminated the following morning. This is known as the AM-PM rule.

The conception rate for first heat service, relative to hours after detection of oestrus, can be seen in Figure 5.

INSEMINATION TECHNIQUE

Before anyone can artificially inseminate a cow and be confident that the cow will conceive, they must first be familiar with the equipment and techniques. Diagram 6 shows the structure of a Liquid Nitrogen (LN) container and its components.

![Diagram 6: Cross Section of a Liquid Nitrogen Container.](image)
Semen is stored at -196°C in liquid nitrogen in special vacuum containers. These containers are made of either aluminium or stainless steel. Stainless steel provides a more durable container. Selection of the most suitable LN container should be based upon its working life and the unit's storage capacity relative to its overall size. Working life is the time between first filling the unit and refilling when the container is continually being used.

Within each container are a number of canisters (buckets) which are removable metal cylinders with long upright handles reaching to the top of the container. These allow initial identification of semen and access to the semen.

Depending upon the height of the buckets, they may contain lifters or an 'L.' shaped handle to facilitate the raising of the canister's contents to the top of the cylindrical section.

Goblets are plastic cylinders which are sealed on one end. They fit neatly into half height buckets and stack double in full height buckets. They provide a convenient way to store semen and hold liquid nitrogen which minimises temperature variation as the semen is raised or lowered within the container. Within each goblet are mini-goblets which vary slightly in size and shape but as a general rule hold 10 or 20 mini-straws (0.25 ml) or 5 to 10 medium-straws (0.5 ml). These mini-goblets allow for additional identification of the semen. They may hold liquid nitrogen which is especially important during the transfer of semen from one LN container to another.

When semen is collected from a bull, it is processed and placed in straws or narrow tubes which are available in two sizes, 0.25 ml or 0.5 ml. Prior to filling the straw with semen, the processor prints relevant details on the side. Straws have a double plug of wick-like material in one end. The semen is sucked into the straw through the open end which is then sealed either by crimping or using a powder plug which later solidifies to form the seal. Before the straw is used, the processor's plug is cut off (normally 3-8 mm long) and the manufacturer's plug provides the basis for a plunger to expel the contents.

The equipment used in AI is illustrated in Plate 4.
ARTIFICIAL INSEMINATION USING STRAWS

‘Catch the cow’

Once the required cow has been restrained, her identification should be recorded. The inseminator must then prepare the equipment, confirm the name of the bull required and correctly identify the straw to be used.

A large neck thermos flask is required to hold warm water (35-36°C) at a depth which will not allow water to enter the top of the straw, i.e., less than 12 cm.

The pistolette is prepared by withdrawing the plunger sufficiently (approximately 15 cm) to allow the straw to be loaded into the barrel of the insemination gun.

The required straw is selected within the liquid nitrogen container using the straw, plug colour and straw size as aids to identification. Gently flick the straw to remove any liquid nitrogen. Place it in the warm water with the manufacturer’s plug downwards. When selecting the straw from the container, the bucket should not be withdrawn past the frost line in the neck of the container, i.e., approximately 50 mm from the top. Provided the goblet is full of LN, the bucket may be held in the neck for up to 45 seconds before being returned to its original position.

Thawing takes approximately 15-20 seconds after which the straw is removed from the water and wiped dry in a paper towel to remove any traces of water. Care must be taken to prevent contamination of the end of the straw containing the processor’s plug. A final check should be made to ensure correct bull identification.

ONCE A STRAW IS THAWED, IT MUST BE USED OR DISCARDED.

Place the straw, with the wick end towards the plunger, in the pistolette, making sure it is kept out of ultra violet light and free of dust and other contaminants. It is good practice to assess the temperature of the barrel of the pistolette to avoid a marked temperature variation. Semen may suffer shock if the temperature of the steel pistolette is significantly different from that of the straw.

Using a pair of sharp clean scissors, cut the straw squarely in the airspace below the processor’s plug. This cut must be at right angles to the straw to allow a good tight contact between the straw and encasing plastic sheath. Two types of plastic sheaths are available. Mini-straws require a small adaptor inside the sheath, while others do not. Universal sheaths contain an adaptor and can be used for both straw sizes.

Once the straw has been cut, the pistolette and straw are slipped into the sheath and the plastic locking washer on the pistolette is twisted tightly into place. Once the pistolette is loaded, the plunger is forced in until a blister of semen protrudes from the end of the sheath. Care must be taken to ensure that the end of the sheath containing the semen does not become contaminated before insertion into the cow’s vagina.

By carrying the pistolette between the teeth, the inseminator’s hands are free to enable him to put on a glove, tear off a length of paper towel, (tissue size), open and close gates and other necessary activities. Should the sheath become contaminated with faecal material etc., then it must be discarded and replaced with a clean sheath. When approaching the cow, one must be careful not to bump the sheath on the open end as this could result in contamination. Avoid direct sunlight on the straw and semen at all time.
* When approaching the cow, remember that any additional undue stress decreases the likelihood of conception. Lift the tail with the free hand and insert the gloved cone-shaped hand with a twisting motion into the rectum, being careful not to be too aggressive as it is possible to rupture the rectal wall.

* Find and grasp the cervix and with the free hand, wipe the lips of the vulva removing any faecal or extraneous material. See Diagram 7.

![Diagram 7: Correct Insemination Technique.](image)

* Draw back on the cervix and at the same time depress the wrist and forearm to open the vulva and insert the pistolette without contaminating the end. Stretch the cervix firmly forward to allow the pistolette to be passed through the vagina to the cervix, thus avoiding vaginal folds. The pistolette must initially be passed into the vagina pointing upwards at an angle of almost 45°. It is then passed parallel to the dorsal wall of the vagina, to avoid entering the sub-urethral diverticulum or urethra.

* Once the tip of the pistolette has reached the os cervix, the inseminator must pass the pistolette through the cervical canal by applying gentle pressure on the pistolette and manipulating the cervix. The cervix must be manipulated by the hand in the rectum to thread the straight pistolette past each cervical transverse annular fold. See Diagram 7.

* Once the pistolette is through the cervix approximately 5 mm and can be felt through the uterine wall using the gentle touch of the index finger, 2/3 of the semen should be slowly deposited. The pistolette should then be withdrawn 1/3 of the way back into the cervix and the remainder of the semen deposited between the cervical folds. At all times care should be taken that the lining of the uterus, cervix and vagina is not injured in any way. Bleeding and bruising must be avoided.

Blood is spermicidal.
On occasions when the cows oestrus period is very short, (particularly Bos indicus breeds) or the insemination is being performed greater than 12 hours after the cow was observed to be on heat, it is advisable that the complete dose of semen be deposited at the utero-cervical junction.

- Following deposition of the semen and withdrawal of the pistolette, the reproductive organs should be gently massaged to stimulate the release of oxytocin.

- To remove the sheath and straw from the pistolette, grasp the sheath with the gloved hand and using a twisting motion release the plastic locking washer. Remove the sheath leaving the washer on the pistolette. Again, check the name and breed of the bull and batch number of the semen on the straw.

- Dispose of the used paper towels, sheaths and gloves in an appropriate rubbish receptacle to avoid littering the area and possible contamination from the used sheath etc.

- Let the cow go free.

- Record both cow and bull identification, the date of insemination and any comments relating to the insemination.

- At the completion of each AI programme clean all equipment thoroughly. Be careful to use clean water as the final wash to remove all traces of antiseptic or detergent.

**ARTIFICIAL INSEMINATION USING AMPOULES**

Almost all bovine semen is now placed in straws, whereas in the past some semen was processed in 1 ml ampoules. Currently, there is very little bovine semen still available in this form. However, should anyone have the need to use ampoules, the procedure for the actual insemination is similar to that when using straws. Different equipment is used.

Ampoules are small glass vials filled with 1 ml of processed semen and stored in canes or 'U' shaped strips of metal that hold up to 7 ampoules stacked vertically. The canes are stored in a bucket in the LN container. When thawing an ampoule of semen, raise the bucket and lift the cane to the frost line in the neck of the container to gain access to the first ampoule. Place it in iced water at 4°C. Thawing should be completed in 30 seconds.

Assemble the syringe connector onto the 2 ml syringe and push a new pipette firmly into the opposite end of the connector, using a little moisture for lubrication. Withdraw the plunger of the syringe 1 ml. Ensure that the pipette, especially the tip, does not become contaminated.

Remove the ampoule from the iced water, confirm the bull identification and gently flick the neck of the ampoule if necessary to remove bubbles of semen, leaving only air in the neck. Cut or file around the ring on the neck of the ampoule to assist a clean break when the neck is broken off using gentle pressure.

Suck the semen into the pipette after first ensuring that at least 1 ml of air is still in the syringe. Place the empty ampoule over the end of the pipette until it is ready to be used, in order to keep the end free of extraneous matter. Conduct the insemination in a similar manner to that when using straws. Before withdrawing the pipette, depress the plunger and bend the connector back on itself to expel all semen and avoid any being withdrawn in the pipette.
Avoid exposing the semen to contamination and sunlight during the procedure.

Pipette, disposable glove and paper towel should be discarded after each insemination and rubber connector and syringe kept clean and maintained correctly.

SEMEN COLLECTION, EVALUATION AND PROCESSING

COLLECTION

The aim of semen collection is to obtain high quality uncontaminated semen. High standards are set for those involved in the collection and processing of semen to ensure that it is of the highest possible quality. The procedures involved in the collection process are designed to minimise stress factors which can reduce semen viability.

There are several methods of semen collection, two of which are routinely used to obtain semen for processing and subsequent sale. The equipment most commonly used is shown in Diagram 8.

The most common methods are:

1. Artificial Vagina
2. Electro-ejaculation

Other methods are:

3. Massage of accessory sex glands
4. Recovering semen from the vagina

1. Artificial Vagina

The Artificial Vagina (AV) is used to simulate normal mating. Stimulation by temperature, pressure and friction initiates the ejaculatory response after the donor bull has mounted a decoy or teaser animal. Because bulls are responsive to change, a preparation and collection routine must be established if consistent results are to be obtained. Allowing the bull to see others mount, leading the bull to the teaser a number of times and false mounts, will increase his sexual desire (libido) leading to a vigorous thrust and the ejaculation of good quality semen.

The artificial vagina is made up of a firm outer cylindrical case 250 mm to 350 mm long and 65 mm to 75 mm diameter containing a vulcanised air/water valve. A soft thin latex inner liner is attached by placing it into the outer case and turning the ends back over each end of the case. The space between the inner and outer sections is then filled with warm water at 42°C and sufficient air to obtain the pressure which will initiate the sexual response. A latex drainer cone and graduated collection tube is attached to one end of the AV.

Semen is collected with an AV according to demand. Collections are usually made once or twice weekly (every fourth day). This causes little or no decline in semen quality. For a bull to
work effectively with an artificial vagina he must be structurally sound in his rear legs, back and all other muscles and bones used in the mounting procedure. Some bulls are reluctant to mount a teaser animal and ejaculate with their penis deflected to one side in the AV.

Impotent bulls or those which cannot be collected using the AV can often be ejaculated using an electrical device.

THE TWO MOST COMMONLY USED AIDS IN SEMEN COLLECTION

(1) Artificial Vagina (A.V.)

![Diagram of Artificial Vagina](image)

Radiator Hose
Length: 30-40 cm.
Diam: 7 cm.

1,2,3 - Rubber retaining bands

(ii) Electroejaculator

![Diagram of Electroejaculator](image)

Cylindrical Probe
Length: 340 mm.
Diam: 60 mm.

Diagram 8: (i) Artificial Vagina (ii) Electro-ejaculator
2. Electro-Ejaculation

The principle of electro-ejaculation is based on the stimulation of the sympathetic and parasympathetic nervous systems. The release of semen is stimulated by passing a fluctuating current between two electrodes on a probe placed in the bull's rectum.

The ejaculator consists of a cylindrical probe which is approximately 340 mm long and 60 mm thick and a control unit.

The bull should be restrained in a crush because stimulation causes vigorous contraction of muscle groups, particularly those of the back and hind legs. The underline of the bull should be washed to remove loose hair and dirt, the prepucial hairs clipped and the sheath irrigated with a warm 3% sodium citrate solution. The probe is placed entirely within the rectum so that the main shaft and electrodes do not touch the anal sphincter. The power control knob is used to produce intermittent pulses from the rectal probe as the voltage is increased. The individual response varies considerably but it is common practise to use 2 to 4 second pulses repeated at similar intervals. At approximately 4 volts of power seminal fluid appears, followed by semen at 6 to 10 volts. The semen is collected using any convenient method, whether it be a funnel with an attached collection tube or an elaborate device incorporating a latex funnel and glass collection tube. Bulls generally ejaculate directly into the collection funnel. Others may ejaculate within the prepuce thus requiring the collector to strip the prepuce and allow the semen to drain into the funnel.

Semen collected using electrical stimulation is as fertile as that collected using an artificial vagina. To obtain good quality semen, the person operating the voltage control must be skilled and experienced in the procedure.

The remaining two methods of semen collection are of most use when only a small quantity of semen is required, i.e. microscopic examination.

3. Massage of Accessory Sex Glands

During collection of semen by massage of the accessory sex glands the bull should be restrained. The seminal vesicles are massaged via the rectum with a backward motion until a few millilitres of fluid drop from the sheath. The ampullae are then massaged as the assistant collects the semen in the collection funnel and tube. This method is often unrewarding and the quality of the semen is usually less than that obtained using the previous methods.

4. Recovery from the Vagina

Recovery of semen from the vagina of a cow after she has been served by the bull is an unsatisfactory method of semen collection. Disease causative organisms and other harmful substances present prevent the use of this method when the semen collection is required for processing. It may be a useful technique for evaluating semen quality where no other collection facilities are available.

EVALUATION

There is no single test that can give an accurate indication of the fertility of individual ejaculates. However when several tests are carefully combined, ejaculates which have a high fertility potential can be selected. The fertilizing capacity of semen appears to be primarily a function of the morphology, number, motility and viability of the spermatozoa. Secondary influences are
the physical and biochemical properties and volume of the seminal plasma. Factors of major importance in semen evaluation are:

- Total number of sperm per ejaculate,
- Motility of sperm,
- Percent live normal sperm.

Evaluation of the quality of the semen sample should begin as soon as possible after collection.

**Appearance and Volume**

Fresh raw semen should have a uniform creamy-white, opaque appearance. It should be slightly viscous if sperm concentration is high. A sample which appears to be translucent and watery contains few spermatozoa per ml. Contamination of the semen sample with extraneous material such as hair and dirt should always be avoided. Any indication of the presence of blood either fresh (bright red) or stale (brown) renders the collection unsuitable. The presence of any purulent material may indicate that the sample is a potential source of infection and therefore should be discarded. Some bulls naturally produce good fertile semen which appears to have a slightly greenish tinge.

The volume of the sample is measured in the calibrated collection tube and varies from 4 to 18 ml depending on the bull and method and technique of collection. Raw semen varies in concentration from 100 to 400 million sperm per ml.

**Motility**

The motility of fresh raw semen is assessed when a drop of uniform thickness is placed on a warm microscope slide and examined under low power magnification. Wave motion, mass activity or swirl are observed. Spermatozoa swim in one direction causing stream movement and wave like ripples in the semen. Very good wave motion is seen in samples with high sperm concentration where a high proportion of spermatozoa are actively moving forward.

**Live/Dead Ratio**

To further qualify the relationship between the motility of the spermatozoa and the effective number of spermatozoa per ml of semen, a live/dead stain is used. This technique involves the use of a stain such as 5% Nigrosin and 3% Congo Reg or Eosin, which allows the observer to differentiate between live and dead spermatozoa at the time of staining. The cells which are alive when the stain is applied remain unstained. Dead cells stain red against the dark nigrosin background. One hundred (100) sperm cells are counted and the number of live sperm expressed as a percentage of the total number counted. This is done under high power magnification. The results are highly correlated with visual estimates of motile cells but more accurately define the number of live spermatozoa per ejaculate.

**Density**

The number of spermatozoa per ml of semen or density, together with the volume of ejaculate are the basic factors affecting the quality and hence the number of cow-doses obtained. Density is also one of the most variable semen characteristics. Differences between ejaculates and between bulls may be considerable. Accurate assessment of density can be made through use of a haemocytometer or a spectrophotometer. When a spectrophotometer is used, the opacity of transmission of light through the sample is measured and then converted to sperm density by comparison with a standard set of data.
Using a red blood cell pipette, the appropriate dilutions and a standard haemocytometer, the number of sperm per ejaculate can be calculated in the field at the time of collection.

**Morphology**

Most semen collections contain some abnormal sperm. This is not usually associated with lowered fertility until the proportion of abnormal sperm exceeds 20% of the sample. Abnormalities of the head, midpiece and tail assist in identifying the site of dysfunction in the bulls reproductive system and its severity. For practical purposes, when the sperm are examined for live/dead percentage, they are also examined for abnormalities. As a general rule, misshapen or abnormal sperm are considered to be dead as they have less probability of reaching and fertilizing an ova.

**PROCESSING**

**History**

The volume of the cow-dose and method of packaging has varied considerably throughout the history of artificial breeding. Long term storage of semen became a reality with the development of suitable diluents and improved technology for freezing of semen. Semen was first processed for storage in glass ampoules containing 1 ml of semen. These ampoules were popular in some countries but had many disadvantages including the need to seal them by heat, their tendency to shatter on thawing and inefficient utilisation of storage space. For a time pellets were used. These were formed by pouring drops of diluted semen into blocks of solid carbon dioxide (dry ice). Pellets achieved good results but were difficult to handle and identify. The evolution of the straw concept has been gradual. Just prior to 1965 a 1.2 ml straw which was frozen and stored in carbon dioxide was in limited use. What is now known as the medium straw (volume = 0.5 ml) was introduced in 1965 and replaced by the mini-straw in 1969. The mini-straw is a polyvinyl chloride tube, 133 mm long, 2 mm in diameter and contains a volume of 0.25 ml.

Conception as a result of AI requires that approximately 7.5 million actively moving spermatozoa are placed in the reproductive tract of the cow in the correct position by the correct method. In order to prepare the ejaculate for use the following processing procedures must be adhered to.

1. Evaluation
2. Dilution
3. Cooling, packaging and freezing
4. Evaluation
5. Storage, transport, transfer, identification and hygiene

**1. Evaluation**

The evaluation procedures have been outlined in the previous section and are basic to the success of processing procedures.

**2. Dilution**

Dilution of semen with a specially formulated solution allows each ejaculate to be divided into approximately 200 individual 0.25 ml or 0.5 ml doses, each containing 25 million live
sperm. Although fertilization requires the union of only one spermatozoa and one ova, a very large number of sperm must be included in each dose to ensure that at least 7.5 million live sperm reach the reproductive tract. Deaths of spermatozoa occur during freezing and thawing.

The majority of artificial inseminations are now carried out using frozen semen rather than fresh liquid semen.

Once the semen collection has been examined and found to meet the required standards it is diluted as soon as possible. The solution used to dilute semen must have the following properties:

- non toxic to sperm,
- provide protection against 'cold shock' during freezing and rapid thawing,
- provide nutrients as a source of energy for sperm,
- free from bacteria and other infectious organisms harmful to both semen and stock,
- provide a buffer to prevent harmful shifts in pH as lactic acid is formed,
- increase the physical volume of the semen to allow for the preparation of multiple doses.

Practically all diluents have either egg yolk or milk or a combination of the two as basic ingredients. Several simple carbohydrates, such as glucose, can serve as an energy source for sperm. Penicillin and streptomycin can be used to inhibit a variety of potentially dangerous microorganisms which may infect the collection. They are no substitute for poor hygiene and will not cure an existing infection in the cow's genital tract. When semen is to be frozen, glycerol is added to protect the sperm against the otherwise lethal effects of freezing.

Dilution of semen may be carried out using either a 1 or 2 part diluent. The use of a 2 part diluent is not as convenient as the single part diluent particularly for custom collected semen or semen collected away from the processing laboratory.

Examples of commonly used diluents are:

2 Part

Fraction A. 10% Egg Yolk  
87% Skim Milk  
3% Glycerol  
Fructose 1.25 gm/100ml  
Streptomycin sulphate 1 000 mgm/100ml  
Penicillin 1 000 iu/ml

Fraction B. 79% Skim Milk  
10% Egg Yolk  
11% Glycerol  
Fructose 1.25 gh/100ml

1 Part  
10% vol/vol UHT Milk  
7% wt/vol Glycerol  
1.25% wt/vol Fructose  
Streptomycin sulphate 0.5 mgm/ml  
Penicillin 1 000 iu/ml  
Enzymes  
A glucuronidase 150 iu/ml  
B amylase 10 mgm/ml
The semen should be kept at 35°C for a period of approximately 15 minutes following collection. This allows biochemical changes which enhance fertility to occur and also enables the collector to evaluate the collection and calculate the required volume of diluent. Prior to adding the diluent it is essential to ensure that both the semen and diluent are at the same temperature. When a single fraction of diluent is used, it is diluted to its final volume and cooled at 4-5°C over a 2 hour period. If a two part diluent is used, the semen is diluted first with Fraction A to half its final volume at 4-5°C and then to final volume with Fraction B.

After mixing the semen with diluent and allowing it to stand for approximately 5 hours it can be frozen.

3. Cooling, Packaging and Freezing

Diluted semen is packaged in 0.5 ml or 0.25 ml pre marked straws. On one side of each straw information will be given on the name of the bull, processing centre, breed of bull, batch number or date of processing and 'UL' (unlicenced) if applicable. Each straw has a cotton wick plug in one end which seals that end. By applying a vacuum to the plugged end of the straw, the semen is sucked into the straw. The opposite end is sealed with a sealing powder or by using a crimp heat seal.

Freezing is accomplished by suspending the straws in liquid nitrogen vapour (-145°C) for 7-9 minutes about 1 cm above the liquid. They are then plunged into liquid nitrogen. LN has a temperature of -196°C, ie the liquid boils at a temperature of 196°C below the freezing point of water.

Straws are packed into plastic 'goblets', each of which contains 10 doses. Diagram 9 shows the basic structure of a straw.

*Diagram 9: Structure of a Typical Straw*
4. Evaluation

After each batch of semen is frozen, several straws are thawed and a drop of semen is examined for quality. Straws are thawed in warm water (35°C) in order to ensure that a minimum number of sperm are killed with optimum fertility. There should be a minimum of 10 million live sperm remaining in the dose after thawing. Any sperm that is substandard in quality is discarded.

5. Storage, Transport, Transfer, Identification and Hygiene

Semen is stored in straws (or ampoules) in buckets in liquid nitrogen. It is generally agreed that the duration of storage of semen in liquid nitrogen has little effect on its fertility. However an 8% decline in fertility over 10 years is quoted as a minimum decline rate.

HANDLING AND STORAGE OF SEMEN

Semen, like any other perishable commodity, must be cared for correctly to maintain quality. Care during processing does not guarantee fertile semen, if it has been abused during transport and storage. Viability decreases rapidly when basic handling and storage requirements are not observed. Inseminators are advised to pay attention to the handling and storage of semen and the maintenance of associated equipment similar to inseminating a cow.

PURCHASE, TRANSPORT AND RECEIPT

Semen is stored at processing and distribution centres in bulk liquid nitrogen tanks or in long life field units. It can be purchased from these centres. Semen is transported in normal LN field units or in special Transporter LN containers. Transporters are LN containers with a small capacity and therefore small volume of liquid nitrogen. Their working life is relatively short. Either type of unit contains liquid nitrogen at -196°C and sufficient buckets to hold the ordered semen. The straws will normally be packed with the coloured plug uppermost in goblets containing multiples of 10. Straws may be dispatched in bulk, ie placed loosely in a bucket if a large number of straws from one bull are ordered.

LN containers should always be stored in the upright position. This prevents loss of LN and spillage of straws into the bottom of the container. Recovery of straws from the bottom of the container is often extremely difficult. If the weather is excessively humid or wet, care should be taken to prevent the stopper in the neck of the container becoming wet. If the plug does get wet, it should be dried thoroughly before being reinserted into the container, as moisture will freeze when it comes in contact with the nitrogen vapour and result in an airtight seal which may cause a build up in pressure and explosion of the unit.

Attached to the transporter unit will be a delivery docket. This contains details of the contents including the name and breed of the bull, the number of doses and the number of the bucket containing the respective semen. Colour of the goblet, straw and plug colour/heat seal and the processing centre are also detailed. This should be checked against the stock received and kept for record purposes.

TRANSFER

To transfer semen from the transporting unit to a storage LN container or field unit, the straws must always be contained in goblets with liquid nitrogen. This maintains the straws at a
constant temperature. If a mini-straw is exposed to the air for longer than 2 seconds, 4 seconds for a medium straw, the temperature may rise sufficiently to cause decreased viability of the semen. Critical temperature for storage of semen is -70°C. Transfer of semen should always be carried out in the absence of direct sunlight.

Liquid nitrogen is a colourless, liquified inert gas at -196°C and presents very few problems to the user when handled carefully. However, it should be handled in an open space rather than a confined room and treated with the same respect given to boiling water. Contact with body tissue can cause frostbite which is similar to a burn. When all the semen has been transferred into a unit containing LN, the remaining nitrogen in the transporting unit can then be emptied into the storage unit.

IDENTIFICATION

A rationalised coding system is used and controlled by legislation in States of Australia. This coding system shown in Figure 6 allows easy identification of the semen contained in the straws. The first identification of semen is found on the goblets which are marked with an abbreviation or code for the bull's name and also the batch number. Each straw in turn shows the following information:

a) identity of the processing centre,
b) name of the bull in full or abbreviated form,
c) letter code representing the breed of the bull,
d) the batch number or date of collection of the semen.
e) A colour code identifies the various breed groups. This code is a combination of the colour of the straw and colour of the plug and/or crimp. A list of colour codes is given at the end of this chapter.
f) In the case of unlicensed semen, 'UL' should be written on the side of the wine red coloured straws.

The straws should always be stored with the processor's plug/crimp upwards to aid in identification and also for convenience at thawing. When examining semen in a LN container, the top of the straws should not be lifted above the frost line in the neck of the unit. This frost line is between 50 mm and 75 mm from the top of the unit.

MAINTENANCE AND STORAGE

There is little maintenance required for LN containers provided they are handled carefully and kept in a cool place. LN containers are basically oversized thermos flasks and should not be dropped or jarred in any way. Misuse may cause a break in the inner or outer liners voicing the vacuum which contributes to the 'holding life' of the container. Containers should be checked by:

a) measuring the loss in kg of LN per day over a set period,
b) examining the container for cold spots which indicate gas escaping onto the outer metal case causing a reduction in temperature of the metal. Each type of LN container has specifications stating the acceptable 'holding period' and rate of loss of nitrogen or evaporation.

As the LN evaporates it must be replaced. As a general rule, once the LN drops to a level lower than a one third full, nitrogen should be added to the container. This will keep the straws in LN or immediately above the liquid in the vapour at all times. The cooler the place where the unit is kept, the lower the transmission of heat through the walls into the container and therefore the longer the holding period. Moist damp areas should be avoided as storage places.
HYGIENE OF INSEMINATORS

At all times, inseminators must remember they are performing a professional task and should act accordingly. Hygiene standards should be maintained by ensuring that equipment is kept free of dust and other contaminants at all times. When working over an open LN container, the technician should avoid allowing dust, dirt or fluids to pass through the opening into the container. The equipment used during an insemination should always be clean to avoid cross contamination from one cow to another. New disposable sheaths should be used in conjunction with clean instruments. When moving from one property to another footwear, gloves and any other items which may become contaminated should be kept as cleaned.

In a situation where equipment becomes infected or contaminated by any animal it should be discarded, disinfected or sterilised before being reused. Animal excretions should be considered as contaminants which will adversely affect the fertility of semen and cause depressed conception rates.

NORTHERN TERRITORY OF AUSTRALIA
Stock (Artificial Breeding) Regulations

COLOUR AND LETTER CODES FOR LABELLING AMPOULES OR STRAWS CONTAINING LICENSED SEMEN

<table>
<thead>
<tr>
<th>Breed</th>
<th>Colour of straws</th>
<th>Colour of powder if used</th>
<th>Breed letter code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Friesian</td>
<td>grey</td>
<td>blue</td>
<td>F</td>
</tr>
<tr>
<td>R &amp; W Friesian</td>
<td>grey</td>
<td>violet</td>
<td>R</td>
</tr>
<tr>
<td>Jersey</td>
<td>green</td>
<td>green</td>
<td>J</td>
</tr>
<tr>
<td>Guernsey</td>
<td>yellow</td>
<td>yellow</td>
<td>G</td>
</tr>
<tr>
<td>Ayrshire</td>
<td>blue</td>
<td>blue</td>
<td>A</td>
</tr>
<tr>
<td>A.I.S.</td>
<td>turquoise</td>
<td>blue</td>
<td>S</td>
</tr>
<tr>
<td>Dairy Shorthorn</td>
<td>pink</td>
<td>red</td>
<td>D</td>
</tr>
<tr>
<td>Milking Shorthorn</td>
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<td>blue</td>
<td>M</td>
</tr>
<tr>
<td>Beef Shorthorn</td>
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<td>red</td>
<td>BS</td>
</tr>
<tr>
<td>Poll Shorthorn</td>
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<td>blue</td>
<td>BT</td>
</tr>
<tr>
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<td>brown</td>
<td>red</td>
<td>BH</td>
</tr>
<tr>
<td>Poll Hereford</td>
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<td>BI</td>
</tr>
<tr>
<td>Murray Grey</td>
<td>salmon</td>
<td>white</td>
<td>BM</td>
</tr>
<tr>
<td>Angus</td>
<td>orange</td>
<td>black</td>
<td>BA</td>
</tr>
<tr>
<td>Red Angus</td>
<td>orange</td>
<td>red</td>
<td>CA</td>
</tr>
<tr>
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</tr>
<tr>
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<td>red</td>
<td>BD</td>
</tr>
<tr>
<td>Poll Devon</td>
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<td>blue</td>
<td>BE</td>
</tr>
<tr>
<td>Breed</td>
<td>Colour of straws</td>
<td>Colour of powder if used</td>
<td>Breed letter code</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>------------------</td>
<td>--------------------------</td>
<td>------------------</td>
</tr>
<tr>
<td>South Devon</td>
<td>clear</td>
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<td>BX</td>
</tr>
<tr>
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<td>BG</td>
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<td>CG</td>
</tr>
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</tr>
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</tr>
<tr>
<td>Sussex</td>
<td>clear</td>
<td>black</td>
<td>CU</td>
</tr>
<tr>
<td>Blonde d’Aquitaine</td>
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<td>green</td>
<td>CO</td>
</tr>
<tr>
<td>Fleckvieh</td>
<td>clear</td>
<td>blue</td>
<td>CF</td>
</tr>
<tr>
<td>Maine-Anjou</td>
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<td>black</td>
<td>CM</td>
</tr>
<tr>
<td>Pie Rouge</td>
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<td>blue</td>
<td>CP</td>
</tr>
<tr>
<td>Simmental</td>
<td>clear</td>
<td>blue</td>
<td>CS</td>
</tr>
<tr>
<td>Brown Swiss</td>
<td>clear</td>
<td>violet</td>
<td>B</td>
</tr>
<tr>
<td>Meuse-Rhine-Issel</td>
<td>purple</td>
<td>violet</td>
<td>CI</td>
</tr>
<tr>
<td>Charolais</td>
<td>purple</td>
<td>violet</td>
<td>BC</td>
</tr>
<tr>
<td>Charbray</td>
<td>purple</td>
<td>white</td>
<td>BU</td>
</tr>
<tr>
<td>Chianina</td>
<td>pistachio green</td>
<td>black</td>
<td>CG</td>
</tr>
<tr>
<td>Marchigiana</td>
<td>pistachio green</td>
<td>red</td>
<td>BY</td>
</tr>
<tr>
<td>Romagnola</td>
<td>pistachio green</td>
<td>blue</td>
<td>BZ</td>
</tr>
<tr>
<td>Limousin</td>
<td>black</td>
<td>yellow</td>
<td>CL</td>
</tr>
<tr>
<td>Brahman</td>
<td>black</td>
<td>white</td>
<td>BB</td>
</tr>
<tr>
<td>Braford</td>
<td>black</td>
<td>green</td>
<td>BL</td>
</tr>
<tr>
<td>Brangus</td>
<td>black</td>
<td>black</td>
<td>BN</td>
</tr>
<tr>
<td>Droughtmaster</td>
<td>black</td>
<td>red</td>
<td>BK</td>
</tr>
<tr>
<td>Santa Gertrudis</td>
<td>bright red</td>
<td>white</td>
<td>BJ</td>
</tr>
<tr>
<td>Sahiwal</td>
<td>red</td>
<td>green</td>
<td>BP</td>
</tr>
<tr>
<td>Sahiwal/Jersey</td>
<td>red</td>
<td>yellow</td>
<td>Y</td>
</tr>
<tr>
<td>Sahiwal/Shorthorn</td>
<td>red</td>
<td>white</td>
<td>BQ</td>
</tr>
<tr>
<td>Sindhi</td>
<td>red</td>
<td>violet</td>
<td>BF</td>
</tr>
<tr>
<td>Africander</td>
<td>red</td>
<td>black</td>
<td>BV</td>
</tr>
<tr>
<td>Africander/Shorthorn</td>
<td>red</td>
<td>blue</td>
<td>BW</td>
</tr>
<tr>
<td>Beefmaster</td>
<td>dark blue</td>
<td>red</td>
<td>CB</td>
</tr>
<tr>
<td>Hayes Converter</td>
<td>dark blue</td>
<td>green</td>
<td>CH</td>
</tr>
<tr>
<td>All breeds, alternative</td>
<td>clear</td>
<td>orange</td>
<td></td>
</tr>
<tr>
<td>Unlicensed semen of any breed</td>
<td>clear</td>
<td>wine red</td>
<td></td>
</tr>
</tbody>
</table>

Figure 6: Schedule 4. Northern Territory of Australia, Stock (Artificial Breeding) Regulations. Colour and letter codes for labelling ampoules or straws containing licenced semen.
ORGANISATION AND OPERATION OF ARTIFICIAL BREEDING PROGRAMMES

‘Great ideas need landing gear as well as wings.’

This quotation of Adolph A. Berle Jr. applies extremely well to the organisation and management of an Artificial Breeding programme under Northern Territory conditions. Long term profits will only be derived from programmes based on sound genetic and technical principles. Sound AB procedures enable the user to attain first service conception rates similar to those normally expected in a naturally mated herd grazing similar pasture species. Prior to commencement of any programme, the manager must clearly define the aims and objectives which in turn determine costs, size, time and labour requirement. Good management incorporates selection of suitable cows, experienced labour, good facilities and effective organisation. AB in the NT has particular application in the breeding of replacement herd bulls from a select nucleus cow herd on the property.

Attention to detail contributes to success. The following points should be noted and considered when planning an AB programme.

SEMEN

The method of receipt of semen is outlined elsewhere in the text. The choice of the particular bull is the responsibility of the breeder/manager. He must select the bull on the basis of what that bull can do for his herd. In a bull replacement unit the sire chosen is likely to have a substantial influence on not only the unit but the entire commercial herd when progeny become sires. Progeny will have widespread long term effects on the quality and production of the herd.

The cost of the semen is also elaborated elsewhere. It is sufficient to say that relative to the other costs incurred, semen costs form 30-50% of the cost per cow in the average programme. Semen must be ordered and received in advance of commencement of the programme.

COWS

Cows should be non-pregnant, fertile, disease free, on a rising plane of nutrition, form a suitable genetic base for herd improvement and be individually identified.

Under extensive conditions it is inevitable that one or more pregnant cows become mixed with the group of cows selected for inclusion in an AI programme. Pregnant cows may abort if injected with prostaglandin and will certainly be a discouragement to inseminators watching for heat periods.

A suitably qualified person should check each cow, per rectum, for normal reproductive organs and ovarian activity. Ideally, cows included in an AB programme should have regular heat periods when non-pregnant. As a general rule, heat periods are initiated when cows are between 230-270 kg body weight. As has been discussed in the section on reproductive related diseases, the best cows included in an AB programme are free of infection which may be systemic and/or isolated in the reproductive organs. Pus in the cow’s uterus or uterine infection with campylobacter, trichomonads, leptospira or brucella organisms will have depressed fertility and be a constant problem to the inseminator. Maiden heifers or cows recently calved and not remated to the bull are usually the best candidates for AI.

Empty cows are more prone to show signs of heat when placed on a rising plane of nutrition, eg when there is a flush of pasture growth approximately 6 weeks after a shower of rain. Similar
effects can also be attained by putting the cows into a fresh paddock or even hand feeding. Cows in forward store condition appear to respond best in AI programmes. Over fat cows and non-cycling poor cows are not suitable. Cows with calves older than 3-4 months invariably do not show signs of heat due to the nutritional stress placed on them by the calves. This is the result of a relationship between the amount of milk the calf drinks and the amount of good quality feed the cow can obtain and utilise.

As a general rule, cows in the northern parts of the Northern Territory should not be included in an AI programme if they are wet and suckling a calf. Cows without calves in the Alice Springs and Barkly Tableland districts have a greater potential to cycle but many will cycle normally with a two to three and a half month old calf at foot. Non-lactating or dry cows need a good excuse for being empty and dry if they are to be included in an AI programme.

IDENTIFICATION

All cows must be identifiable. Preference through experience is for two sided numbered tags that can be easily seen and recorded from in front and behind the animal. This is of particular importance when observing the herd for cows on heat in the paddock. To improve legibility of tags, they are best placed in the outer parts of the ear where obstruction to visibility by hair is minimal. Alternatively, the use of 'freeze branding' may be considered. This causes grey hairs to grow in the place of the brand. However, it is of little use on light coloured animals, eg Brahman and Charolais etc.

Whatever the marking method, it must be as permanent as possible for future identification of the cow and her calf. Ear tagging should be done about 6 weeks prior to commencement of the programme. This avoids any undue stress of the animals during the programme. At the same time, animals should be dehorned or tipped if applicable.

AIDS FOR HEAT DETECTION

If steers or modified bulls are to be used to assist in the process of heat detection, they should be put with the cows some weeks prior to commencing the programme. This enables them to adapt to the area and settle down amongst the cows. When steers are to be used they should be injected with the appropriate dose of a long acting testosterone 3-7 days prior to commencement of the AI programme. This allows time for the drug to have full effect. If chin balls are used they should be filled at the start of the programme with an ink of a suitable colour which is clearly visible when the cows backs are marked, eg yellow for red cattle and green for greys. They are then carefully fitted under the jaw of the injected steers 1-2 days prior to the programme commencing. For correct fitting of chin balls ensure that the metal ball responsible for ink release is in a position to effectively mark the cows. The latter section of the chin ball must fit firmly to the animal’s head — not tight enough to wear areas of skin bare or stop the animal from grazing. Neither should it be so loose that it will fall off.

FACILITIES

Prior to any programme commencing, equipment and facilities required must be of a satisfactory standard for use. Sheaths, pistolettes, gloves, scissors, tweezers, liquid nitrogen and cylinders can be prepared and/or purchased at the same time as the semen is ordered. Facilities such as yards, crush, shade cover, water supply at yards and a holding paddock containing sufficient feed, need prior attention and preparation.

Good yards have provision for drafting the cows at least 3 ways, eg cows on heat, cows not on heat and cows already inseminated. Yards should contain a race and crush. The crush need
not necessarily consist of a head bail, but should have either a kick gate, half slide gate or tindal chain to restrain the rear of the animal. Access to the rear of the animal with room to work can be facilitated by gates on both sides and behind the restrained animal. An additional slide gate is then required behind the operator. The crush design in Diagram 10 has all of these features and is effective in practice.

Shade should be provided over the crush and immediate surroundings. Irrigation at the yards helps minimise contamination of equipment with dust and is advisable. Cattle should be worked quietly through the yards with minimal noise to avoid any undue stress. Clanging of metal gates is best kept to a minimum with the use of lubricants etc.

Holding paddocks should be adjacent to the yards. If the holding paddock is any distance from the yard, a laneway between both is useful for moving stock. The paddock must be large enough to contain sufficient feed for the duration of the AI programme, yet not too large to cause mustering difficulties. The larger the paddock, the longer the time required to put all the cows together for heat detection. 2 to 5 square kilometers (0.8-2.0 square miles) paddocks are large enough for up to 200 cows under Central Australian conditions. It is possible to have

Diagram 10: Suitable Crush Design
holding paddocks less than 2 square kilometers depending upon the number of cattle in the programme, acceptable stocking rate for the area and the length of time that the facilities will be required. Cattle in the holding paddock should have access to water at all times. Heavily timbered or extensive scrub in holding paddocks reduces mustering efficiency and adversely effects the heat detection procedure.

Fences around holding paddocks should be secure enough to ensure that stock do not get in or out of the area. This is especially important where bulls are running in the adjacent paddock. Cows on heat are an irresistible temptation.

Hand feeding of the cows in the yard may result in false identification of cows on heat thus decreasing the apparent conception rate.

**LABOUR**

The cattle are mustered and watched both early in the morning and late afternoon. As a general rule, two people are required to muster, hold and identify the cows on heat. The cows observed to be on heat during the AM detection period are recorded by their ear tag number and are drafted off from the mob prior to the PM heat detection period. Cows showing signs of heat in the morning are inseminated in the evening. Similarly, the cows on heat in the evening are inseminated the following morning after the heat observation period.

Once a cow has been inseminated, she may either be placed back with the same group of cows or put in an adjacent paddock where she can be watched for prolonged oestrus.

The same labour used for the mustering is sufficient to work the stock in the yards and inseminate the cows. Due to the concentration of cows coming on heat approximately 72-96 hours after the prostaglandin injection, labour is required for longer periods on those mornings and evenings.

**FACTORS AFFECTING FERTILITY IN CATTLE**

**FERTILITY**

Fertility is the ability of the female to conceive, nourish and expel a normal calf at regular intervals.

**INFERTILITY DISEASE**

Any disease which interferes with the process of reproduction.

**REPRODUCTIVE DISORDERS**

Reproductive disorders encountered in cattle are usually due to one or more of the following factors:

1. Inheritance — GENETIC
2. Management
3. Nutrition
4. Disease
1. Inheritance

Inheritance disorders may be expressed as structural or physiological defects and include albinism, dwarfism, abnormal development of ovaries or testes, freemartins, umbilical hernia, penile deviation etc.

Freemartinism occurs when twins, one male and one female, develop in the uterus at the same time. The female’s reproductive organs are underdeveloped as a result of the transfer of cells from one foetus to the other in their early development. Only the female reproductive organs are affected, the male organs develop normally.

Inherited defects are described as genetic abnormalities. These abnormalities may be visible, e.g. dwarfism, but many are not obvious. Conditions such as premature abortion or weak, slow growing animals may represent an almost invisible but potentially serious economic loss.

Genetic abnormalities are usually caused by recessive inheritance and are generally single gene effects. The source of the recessive genes should be identified and removed from the herd.

Obvious physical abnormalities should be investigated prior to commencing an AI programme. This may involve rectal or physical examination of the cows. Animals with weak hind legs or other obvious physical defects should be culled. In extensive management conditions it is not practical to conduct tests to detect carriers of defective genes causing less visible defects. Merely culling the defective offspring if they are identified will not reduce the incidence of the defect, however, there are a few basic management principles which should be adopted to maintain the incidence of ‘trash’ genes at a minimum.

a) Avoid inbreeding or line breeding.

b) Ensure that bulls purchased from elsewhere and that particularly valuable animals have no history of genetic abnormalities in their sire and dam lines.

c) Cull any sire or dam which continually produces poor doers, or animals with obvious defects.

2. Management

Management aspects of major importance in reproduction are:
- detection of oestrus,
- timing of insemination,
- handling of cattle,
- time of insemination after calving, and
- the inseminator effect.

As discussed previously, accurate detection of oestrus is essential to obtain high conception rates. A rule of thumb for the timing of insemination in Central Australia is — COWS ON HEAT IN THE MORNING SHOULD BE INSEMINATED IN THE EVENING and vice versa.

Quiet, well handled cattle are not essential, but wear and tear on man and beast are reduced with quiet tractable cattle. Stressed or excited cattle have reduced conception rates. This stress can be physiological, i.e. lack of water, or physical, i.e. poor handling. The main problem arising with wild or excitable cattle is that it may be difficult to deposit the semen in the correct position. Excitement and stress cause an increase in adrenalin production which is thought to reduce sperm transfer in the reproductive tract. The more
difficult it is to inseminate a cow because of behaviour the more likely the inseminator is to damage the uterine wall and cause bleeding.

Time of insemination after calving will affect conception rates. The best time to inseminate is 60-90 days after calving. Cows vary a great deal in the time they take to resume cycling after calving but 60 days can be used as a reliable guide in the Alice Springs and Barkly Tableland districts, ie calves about 2 months of age. In the Top End, Brahman cows should be weaned prior to commencement of the AI programme to allow them to begin to cycle. Where nutrition is poor and the cow is supporting a calf, she is unlikely to resume cycling until much later than normal. This failure to resume cycling immediately after calving is caused by lactation and is referred to as lactational anoestrus.

Insemination prior to 60 days after calving results in drastically reduced conception rates. Most cows will not cycle at all during this period and therefore will not be available for insemination.

The HUMAN FACTOR: for good results human errors must be minimised. This is best achieved by strict attention to detail during planning and preparation, maintaining a high standard of hygiene and using the correct insemination technique.

3. Nutrition

It is essential that cows be in good condition (forward store) and preferably on a rising plane of nutrition if conception rates are to be satisfactory.

Cows in poor condition may fail to show signs of oestrus or post service anoestrus may result. In post service anoestrus the cow may cycle, be inseminated, not conceive and fail to cycle again simply because the reproductive system is not functioning normally. Poor nutrition generally results in a lowered conception rate thus increasing the number of inseminations required.

Nutrition, hormone and disease interactions are thought to be the major causes of reduced fertility in the NT.

4. Disease

Although there are many diseases causing permanent and/or temporary infertility only the most common will be dealt with here.

a) Venereal

Venereal diseases are transmitted during the mating process. It is important to note that poor hygiene and/or a careless inseminator may result in infection.

Two of importance in the NT are Vibriosis and Trichomoniasis.

i) Vibriosis

Organism — Campylobacter foetus.

Transmission:
Being a true venereal disease it is spread at service. If a bull becomes infected spread to the breeding herd may be very rapid. Primary or initial infection are evidenced by a
massive reduction in calf numbers or abortion storms. Prolonged infection and associated secondary infections may result in slightly reduced conception rates and calving percentage and are not easily detected. Disease may be present in the herd for a considerable period of time before it is detected.

Effects:
Abortion: This generally occurs at early to mid pregnancy (3-6 months). Retention of foetal membranes may occur and infection causing permanent infertility may result.

Infertility/Return to Service: In the early stages of herd infection a large proportion of females will fail to conceive and subsequently return to service, often at irregular intervals.

Temporary Infertility — Bulls: The disease itself does not cause this infertility but the additional work load imposed by the large number of cows returning to service may cause the bull to become ineffective.

Resistance:
Although up to 15% of females infected may become permanently infertile the rest develop a resistance to the disease. This takes some time to develop and considerable economic losses may be incurred due to the reduced calving percentage.

Diagnosis:
Laboratory Tests: Preputial smear for bulls and cervical mucus for cows.

Herd history, return to service and lowered calving percentages.

Treatment:
Antibiotic treatment may be effective however in infected beef herds it is generally not practical.

Control:
Bulls — Year 1  — Two (2) vaccinations, six (6) weeks apart.
— Booster — at least every 5 years.
— CONTROL MICKIES

Cows and heifers — Where possible vaccinate all heifers.
— Two (2) vaccinations, six (6) weeks apart.
— Cows should be vaccinated every 5 years thereafter.

Rest infected animals for 3-4 months and mate to uninfected bulls or AI. This rest allows animals to build up a resistance.

Remove bulls and use AI to prevent further spread of the disease and to allow resistance to build up in the herd. Not practical under NT conditions.

i) Trichomoniasis

Organism: Tritrichomonas foetus

Transmission:
Transmission occurs at service and up to 90% of females may become infected when it is introduced into a susceptible herd by infected bulls. It may be present for some time
before it becomes apparent. In pregnant cows it can persist in the vagina and cervix from 95 to 163 days. Non pregnant animals can retain uterine infection for 16 to 22 months.

Bulls may not acquire infection until 3 years of age. Severity of infection develops rapidly after 4.5 to 5 years of age.

Effects:
Abortion: If pregnancy develops in infected animals abortions may occur. Trichomoniasis is characterised by early abortions, i.e. 2-5 months.

Infertility, persistent and irregular returns to service due to embryonic mortality.

Pyometra: Is a condition which may arise from the death and decay of the foetus in the uterus. Infection results, the animal does not return to service and is often presumed to be pregnant.

Temporary Bull Infertility: This infertility results from overwork as females continually return to service.

Resistance:
As with vibriosis cattle build up a resistance to the disease. Once again this takes some time and serious economic losses may be sustained through lowered calving percentages in the interim.

Diagnosis:
Laboratory Tests: — preputial mucus sample from infected bulls,
— vaginal mucus from infected cows sampled when on heat,
— specimens from recently aborted foetuses and placental fluids.

Herd history of early abortions and continual return to service.

Treatment:
Current treatment is severe, requires prolonged administration and is not recommended.

Control:
Pregnant Cows: Allow 5 months sexual rest post calving and remate to tested negative bull.

— Infected Empty Cows can be mated to AI.
— Mate all cows and when pregnant follow as for pregnant cows.
— Mate heifers to clean bulls.
— Control MICKEY BULLS.

Obviously both methods of control have their associated management problems.

b) Other Diseases Affecting Fertility

Other reproductive diseases of importance are Brucellosis and Leptospirosis. Of the two, Brucellosis is of greatest concern in the Northern Territory at present.

i) Brucellosis

Brucellosis is an infectious disease of cattle caused by the organism Brucella abortus. The disease is also known as contagious abortion or Bang's disease.
Transmission:
Brucella abortus multiplies in the uterus of infected pregnant cows. When the cow aborts the foetus, foetal membranes and fluids containing the organism contaminate the pasture. The organism is also expelled in urine, faeces and milk.

The organism can survive for up to 2 months in cool shaded areas. The usual method of infection is by ingestion of contaminated pasture, foetal membranes (afterbirth) or water contaminated with foetal fluids, urine or faeces.

In mature non-pregnant females the bacteria usually move to the udder until pregnancy occurs when they return to the uterus.

Brucella can be transmitted to man via the conjunctiva, orally or by contaminated cuts and abrasions.

Effects:
Abortion: In the uterus the organism causes gradual death of those parts of the foetal membrane responsible for maintaining the blood supply to the calf (cotyledons). The calf usually dies and is aborted. Abortion usually occurs late in pregnancy, generally in the final third, ie 6-9 months. This is not always the case and will depend on the stage of pregnancy at the time of infection and the degree of infection.

An infected animal introduced into a susceptible brucellosis free herd may rapidly spread the disease, leading to what is known as an abortion storm, where 60% or more cows may abort.

Cows which have aborted once will build up a tolerance to the disease. Although they may not abort again they may remain carriers of the disease.

Neonatal Losses: Infected cows may produce normal healthy calves. However most infected animals which carry a calf to full term give birth to dead or very weak calves which die soon after.

Retained Foetal Membranes: With most abortions the placenta or afterbirth is retained. This decays in the uterus causing infection which normally results in reduced fertility or infertility.

Temporary or permanent infertility may occur in infected bulls.

In man the organism causes a disease known as Undulant Fever which may be severe and is difficult to treat.

Diagnosis:
Blood Testing: Blood taken from all female cattle and bulls is tested in the laboratory for evidence of the presence of the organism.

- Laboratory culture of the organism from aborted calves, membranes, blood or milk.
- History of late abortions, retained membranes and breeding problems in the herd.

Treatment and Control:
- Ensure that only tested free cattle are brought onto clean properties.
- Blood testing and culling.
- Vaccination using 45/20 vaccine (no longer applies).
ii) Leptospirosis

Organism:
Leptospira pomona, L. hardjo and L. tarassovi

Transmission:
The leptospira organisms are excreted via the urine contaminating pasture and water. Intermediate hosts such as rodents and pigs assist in the spread of the disease.

Methods of infection include:
- drinking contaminated water,
- eating contaminated pasture,
- organisms may enter through the skin and mucous membranes.

Effects:
All stock are susceptible but symptoms vary according to age, sex and stage of pregnancy.

Calves: Infection may result in —
- sudden death,
- passage of red urine.

Non-pregnant females and males will not usually show symptoms.

Pregnant Females:
- abortions at 5-7 months of pregnancy,
- abortion storms.

The pregnant uterus becomes susceptible to infection at about 4 months into pregnancy.

As the afterbirth is rarely retained in abortion cases; breeding potential is not greatly impaired by leptospirosis.

Humans are susceptible.

Diagnosis:
- Positive identification is possible only by isolation of the organism in urine, blood or foetal material.
- History of abortion.

Treatment:
Costly and impractical for animals other than valuable stud stock.

Control:
Vaccination of breeding stock with a bivalent vaccine:
- initial vaccine at mating,
- second dose 4-6 weeks later,
- booster dose during last month of pregnancy.

Vaccinate cattle being introduced into an infected herd.

Calves:
If losses are occurring vaccinate at 3 months of age and again 4-6 weeks later.
SELECTION AND BREEDING

To be effective, selection practices must be based on sound economic principles, environmental influences and the management resources available. Selection determines future productivity of the herd, therefore practices must be implemented with a long term view.

The skill of selection is not so much the ability to recognise differences between animals, but rather knowing how much emphasis to place on those differences to achieve the desired effect.

Most of the characters of practical significance in cattle, ie fertility, growth rate and body weight, are under the control of many genes and are influenced by environmental conditions and management. Within any group of animals, considerable variation in individual performance can be seen, ie growth rate, frame score, fertility and temperament.

Variation in individuals in a group occurs as shown in Figure 7. The greater the variation in the herd the greater the potential for selection.

![Figure 7: Variation of Individuals in a Group.](image)

The beef breeder can take advantage of this situation by implementing selection programmes and retaining those animals which fall into the high portion of the graph as the basis of a nucleus herd (breeders) or as commercial bull replacement.

It is important to note that many of the differences between individuals are a result of environmental influences rather than superior genetic makeup.

HERITABILITY

Heritability is the extent to which differences between animals are transmitted from one generation to the next. A character can be assessed and is said to be highly heritable when environmental effects on the variation of that character are small. The character should be assessed independently of environmental influences.

Selection practices should be based on sound genetic principles to ensure that genetic progress is made. Consideration of the heritability of the various economically important traits and the effect of selecting for particular traits is essential. Excessive emphasis on selection for a particular character may be detrimental to the overall herd in the long term if other characters of equal or greater importance are disregarded. Figure 8 gives the heritabilities of particular characters expressed as percentages.
<table>
<thead>
<tr>
<th>CHARACTER</th>
<th>APPROXIMATE LEVEL</th>
<th>RANGE (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reproduction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conception</td>
<td>Low</td>
<td>0-5</td>
</tr>
<tr>
<td>Calving interval</td>
<td>Low</td>
<td>0-10</td>
</tr>
<tr>
<td>Calving ease (heifers)</td>
<td>Medium</td>
<td>15-50</td>
</tr>
<tr>
<td>Semen quality</td>
<td>Medium</td>
<td>25-40</td>
</tr>
<tr>
<td>Scrotal circumference (18 months, per kg)</td>
<td>Medium - High</td>
<td>20-50</td>
</tr>
<tr>
<td>Serving capacity (18 months)</td>
<td>Medium - High</td>
<td>30-90</td>
</tr>
<tr>
<td>Maternal ability</td>
<td>Medium</td>
<td>20-40</td>
</tr>
<tr>
<td>Milk yield</td>
<td>Medium</td>
<td>20-25</td>
</tr>
<tr>
<td>Conformation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weaning score</td>
<td>Medium</td>
<td>25-35</td>
</tr>
<tr>
<td>Body length</td>
<td>Medium</td>
<td>25-45</td>
</tr>
<tr>
<td>Chest girth</td>
<td>Medium - High</td>
<td>25-55</td>
</tr>
<tr>
<td>Withers height</td>
<td>Medium - High</td>
<td>30-50</td>
</tr>
<tr>
<td>Growth</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Birth weight</td>
<td>Medium</td>
<td>35-40</td>
</tr>
<tr>
<td>Weaning weight</td>
<td>Medium</td>
<td>25-30</td>
</tr>
<tr>
<td>Gain - birth to weaning</td>
<td>Medium</td>
<td>25-30</td>
</tr>
<tr>
<td>Yearling gain (pasture)</td>
<td>Medium</td>
<td>30-45</td>
</tr>
<tr>
<td>18 month weight (pasture)</td>
<td>Medium - High</td>
<td>40-50</td>
</tr>
<tr>
<td>Mature cow weight</td>
<td>High</td>
<td>50-70</td>
</tr>
<tr>
<td>Carcase (U.S.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dressing percent</td>
<td>Medium - High</td>
<td>30-55</td>
</tr>
<tr>
<td>Carcass weight/day of age</td>
<td>Medium</td>
<td>25-45</td>
</tr>
<tr>
<td>Tenderness</td>
<td>High</td>
<td>50-70</td>
</tr>
<tr>
<td>Temperament</td>
<td>Medium - High</td>
<td>25-50</td>
</tr>
<tr>
<td>Cancer eye susceptibility</td>
<td>Medium</td>
<td>20-40</td>
</tr>
<tr>
<td>Eyelid pigmentation</td>
<td>High</td>
<td>45-60</td>
</tr>
</tbody>
</table>


Figure 8: Heritability Estimates for Some Characters in Beef Cattle.
<table>
<thead>
<tr>
<th>Associated characteristic for which genetic change is calculated.</th>
<th>When direct selection has achieved 1 kg of extra Weaning weight</th>
<th>1 kg of extra Yearling weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth weight (kg)</td>
<td>0.13</td>
<td>0.09</td>
</tr>
<tr>
<td>Weaning weight (kg)</td>
<td>(1.0)</td>
<td>0.4</td>
</tr>
<tr>
<td>Yearling weight (kg)</td>
<td>1.1</td>
<td>(1.0)</td>
</tr>
<tr>
<td>Mature weight (kg)</td>
<td>2.0</td>
<td>1.3</td>
</tr>
<tr>
<td>Weight at puberty in heifers (kg)</td>
<td>0.5</td>
<td>0.8</td>
</tr>
<tr>
<td>Age at puberty in heifers (days)</td>
<td>-1.1</td>
<td>-0.4</td>
</tr>
<tr>
<td>Weaning grade (points)#</td>
<td>0.01*</td>
<td></td>
</tr>
<tr>
<td>Final grade at a given age (points)#</td>
<td>-0.02*</td>
<td></td>
</tr>
<tr>
<td>Fat depth at a given age (mm)#</td>
<td>0.21</td>
<td>-0.01</td>
</tr>
<tr>
<td>Fat depth at a given weight (mm)#</td>
<td>-0.12</td>
<td>-0.04</td>
</tr>
<tr>
<td>Carcass weight at a given age (kg)#</td>
<td>0.65</td>
<td>0.74</td>
</tr>
<tr>
<td>Retail product at a given age (kg)#</td>
<td>0.75</td>
<td>0.45</td>
</tr>
<tr>
<td>Retail product at a given weight (kg)#</td>
<td>0.05</td>
<td>0.01</td>
</tr>
</tbody>
</table>

* If the genetic progress from direct selection was say 1.5 kg per year, then multiply the value in the column by 1.5 to find the genetic change in the associated characteristic. Thus for mature weight for example with a value of 1.3 kg in the yearling weight column: if genetic change in yearling weight due to direct selection is 1.5 kg per year, then associated genetic change in mature weight = 1.5 x 1.3 = 1.95 kg per year. For age at puberty in heifers, a 0.6 kg increase achieved by direct selection for weaning weight will be accompanied by 0.6 x -1.1 (= -0.66) days change in age at puberty.

# Feedlot data from North America.

* The usual range differed between studies (e.g. 3-, 5-, 7-, or 17- point scales).


Figure 9: Genetic Change in Associated Characteristics When Selection is for Weaning or Yearling Weight.
Similarly associated characteristics must be considered when selection for a specific character is carried out. Selection for high weaning weight may be at the expense of fertility. Selection for high weight gain results in high birth weight and therefore increases the likelihood of difficult births. In the more extreme climate, environment and extensive management systems in the NT it is possible that cow fertility may be more variable and more heritable than in other areas. This means that there may be more scope for improvement, but further research is required to confirm this. The greater the variation the greater the effect of selection will be.

Selection of bulls for higher growth rates and therefore heavier body weight at 18 to 24 months results in selected bulls having larger scrotal circumferences and increased fertility.

In one instance where high fertility was actively sought, body size tended to decrease. Lowered body weight reduced market suitability.

Generally fertility characters have a low heritability and selection for these characters will result in a slow response. Carcass and confirmation characters are usually highly heritably and more rapid progress can be achieved by selection.

Selection for two characters which occur independently of each other will result in a halving of the expected rate of genetic progress for each character. It follows then that the greater the number of independent characters that are selected for at one time, the slower the progress towards the final objective will be. The basic theory of heritability is illustrated in the example below on other characters. This example was drawn from a NSW Agnote, (Adgex 420/33), November 1979.

The two breeding objectives considered are selection for increased weaning and yearling weight. The effect of direct selection for these two characters on other important production traits is shown in Figure 9.

To determine what response can be expected if characters undergo selection it is necessary to have accurate recorded data about that character in your herd and a heritability range for it. Because of environmental effects, genetic gains may not be detected and observed gains may not be genetic.

For example, a commercial beef producer calculates that on average his breeders require 3 services per conception. He takes a nucleus herd for which the recorded data available indicate an average of 2 services per conception. This characteristic has a heritability range of 0-5% (av = 3%).

The progeny of the nucleus herd would show a genetic gain of 3% of 1 (the difference between the average of the two groups).

Therefore the progeny would require an average on 0.03 less services per conception than if there has been no selection. However, if prevailing environmental conditions were favourable, eg animals all in forward store condition and on a rising plane of nutrition the improvement may appear to be greater than it actually is. Gains such as this are rarely detectable by eye.

**SELECTION PRIORITIES**

Beef prices are only part of the income equation. To achieve a steady return on investment while costs are increasing at a greater rate than returns, as is the current economic climate, then efficiency of production must be continually upgraded. Fertility, disease control, nutrition, labour availability and cost, together with market outlets all influence profitability.
Analysis of selection practices in terms of economic benefits is of ever increasing importance. Breeding programmes should be evaluated in the light of the requirements of the producer, the retailer and the consumer. Market requirements change over time and it is up to the individual producer to define the market he is producing for, be aware of trends and act accordingly. The economic importance of production characters must be defined and selection priorities rationalised.

Production characteristics such as fertility affect economic returns in an absolute manner. Economic beef production can only be realised by maximising the number of live calves born. Traits such as weight gain affect returns by degree and are secondary in importance to the actual production of a live calf. In other words, if calving percentage is low the overall affect on income is far greater than a low growth rate.

Characters affecting reproduction have low heritabilities and high economic importance, while carcass characteristics have both high heritability and economic importance.

The percentage of calves weaned to cows mated is the most important factor controlling differences between herds in efficiency of production.

Bearing in mind the environmental and management constraints the producer must list fertility as his first selection priority. A live calf born per cow each year is fundamental to economic beef production. Where a practical opportunity arises to select for fertility, as it does with AI, both barren and irregular breeders should be either speyed or culled immediately. Pregnancy testing is a simple practical aid to determining herd fertility.

Factors affecting selection for high fertility which should be considered include:

a) Milking ability of the cow has an important influence on weaning weights,

b) Growth rate of the offspring influences the final weight of sale stock. It is a highly heritable trait therefore responds quickly and positively to selection. BEWARE an increase in growth rate could mean a decrease in fertility.

c) Structural faults such as hernias, poor muscle development, weak hind quarters or twisted feet may be detrimental to fertility and survival and require long term selection programmes to eliminate them from the herd. Animals with visible genetic faults should be culled immediately and their parents identified and eliminated from the herd.

d) Selection for 'good' CONFORMATION probably forms the basis for most selection programmes in the NT at present. Conformation includes such characters as muscle development, eye pigmentation, skeletal form, horn/polled and frame size. Selection for these traits usually results in a rapid response. However, this may again be to the detriment of traits such as fertility. Although conformation serves as an indication of the animals production type, a knowledge of the standards for individual production types is necessary if selection is to be effective. The producer must ensure that the criteria used during assessment are objective and real. Carcass characteristics considered must be measurable and relate to muscle development rather than fat cover.

e) Sire and dam effect. As the one bull can fertilize at least 40 females in one mating season, (many more with AI), the effect of bull selection will be much greater than that of female selection on the herd.

Selection of cows which are superior to the average cow is much more difficult than selecting superior bulls, simply because only 3-5% of the herd consists of bulls and greater selection pressure can be exerted.
<table>
<thead>
<tr>
<th>Trait</th>
<th>Type of Cattle</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bulls</td>
</tr>
<tr>
<td><strong>Traits we can see</strong></td>
<td></td>
</tr>
<tr>
<td>1. Sex character</td>
<td></td>
</tr>
<tr>
<td>a. Masculinity</td>
<td>✓</td>
</tr>
<tr>
<td>b. Femininity</td>
<td></td>
</tr>
<tr>
<td>2. Testicular size</td>
<td>✓</td>
</tr>
<tr>
<td>3. Udder soundness</td>
<td></td>
</tr>
<tr>
<td>4. Muscle type and design</td>
<td>✓</td>
</tr>
<tr>
<td>5. Body composition</td>
<td>✓</td>
</tr>
<tr>
<td>a. Muscle</td>
<td></td>
</tr>
<tr>
<td>b. Bone</td>
<td>✓</td>
</tr>
<tr>
<td>c. Fat</td>
<td>✓</td>
</tr>
<tr>
<td>6. Frame (Maturity pattern)</td>
<td>✓</td>
</tr>
<tr>
<td>7. Structural soundness</td>
<td>✓</td>
</tr>
<tr>
<td>(feet and legs)</td>
<td></td>
</tr>
<tr>
<td>8. Health</td>
<td>✓</td>
</tr>
<tr>
<td>9. Disposition</td>
<td>✓</td>
</tr>
<tr>
<td><strong>Traits we can measure</strong></td>
<td></td>
</tr>
<tr>
<td>1. Birth weight</td>
<td>✓</td>
</tr>
<tr>
<td>2. Weaning weight</td>
<td>✓</td>
</tr>
<tr>
<td>3. Yearling weight</td>
<td>✓</td>
</tr>
<tr>
<td>4. Mature weight</td>
<td>✓</td>
</tr>
<tr>
<td>5. Progeny performance</td>
<td>✓</td>
</tr>
<tr>
<td>6. Frame score</td>
<td>✓</td>
</tr>
<tr>
<td>7. Testicular size</td>
<td>✓</td>
</tr>
<tr>
<td>8. Breeding soundness</td>
<td>✓</td>
</tr>
<tr>
<td>9. Pelvic area</td>
<td></td>
</tr>
<tr>
<td>10. Carcase traits</td>
<td></td>
</tr>
</tbody>
</table>


*Figure 10: Traits Used in Beef Cattle Selection Programmes.*
Figure 10 lists the major traits used in beef cattle selection programmes. In order to successfully select and evaluate stock the producer must develop the necessary skills. These include:

a) Mental image of 'ideal' types for the market in which he is operating.

b) Keen power of observation.

c) Ability to interpret and incorporate production data and performance records in animal selection.

d) Ability to co-ordinate live animal selection with carcass evaluation. A trip to the abattoirs when cattle are being slaughtered is always beneficial if you collect the relevant data.

e) Ability to be objective in application of selection priorities.

f) Ability to give valid reasons for selection practices and to evaluate each trait in terms of its total value and effect.

SELECTION AND AI PROGRAMMES IN THE NT

Environmental and managerial resources influence considerably the potential genetic gains from an AI programme and must be considered before a benefit/cost analysis can be conducted.

Although there is little scope for large scale AI programmes at the moment, it appears there is sufficiently strong evidence to support the practicability of individuals or groups of pastoralists breeding their own bull replacements (BYOB).

Principles of Selection

Before commencing a breeding programme ensure that you define exactly what you want to improve in the herd. Define your objectives, look at your markets and determine what type of animal is required. Do not attempt to breed for all markets.

Types of improvement in the herd can be:

a) Immediate gains from culling poor producers.

b) Selecting superior replacements so that the next generation will be improved.

In any herd for a given character there will be a small number of very poor animals, a few poor animals, a large number of average animals, a few good animals and a small number of very good animals, relative to the average for the character in the herd. Immediate gains can be made by culling the very poor and poor animals if the character is heritable.

Selection of superior replacement for the breeding herd ensures that the progeny or following generation are genetically superior to the previous generation. Ongoing selection should aim at continually improving the AVERAGE ability of the herd. See Figure 11. This is very definitely a long term project and plans should be made for 10-12 years in advance.
Increase in average performance of herd with successive calf drops.


Figure 11: Improvement of the Average Performance of the Herd with Regard to a Particular Character(s).

The rate of improvement per year for a character depends on:

a) Accuracy of selection.

b) Heritability range for the character/characters.

c) Amount of variation between individuals for a particular character and therefore the intensity of selection which can be applied.

d) The number of characters considered when selecting replacement. The greater the number, the less improvement there will be for any one character.

e) Genetic associations between characters selected for or against. If associations are positive, selection decisions about one character will have a positive influence on the other. If the association is negative the characters will work against one another. Selection for high yearling weight for heifers would tend to increase birth weights. If milking ability does not increase proportionally then it is likely that the genetic potential for growth will be realised by the calf. In addition the heifer or cow may be stressed considerably by the increased demands of the calf.

f) Time when characters can be measured in the animal’s life, ie weaning weights can be measured at an early age but ability to produce a calf every 12 months cannot be measured until much later in life.

g) The basic design of the breeding programme.
Figure 12 outlines the inputs and decisions which must be made in order to design a breeding programme. These are applicable to both commercial and AI programmes and success is dependent on objectivity and adherence to the plan.

INBREEDING

When breeding bull replacements it is wise to consider how much inbreeding is likely to occur. Naturally the more closely related the animals are, the more inbred their calves will be. Sires and dams with common ancestors may have genes in common. Offspring may get two copies of the same gene which could be harmful.

1. A calf from a full brother-sister mating is 25% inbred.
2. A calf from a half brother-sister mating is 12.5% inbred.
3. Calves from father-daughter or mother-son matings are 25% inbred.
4. A calf from a grandmother-grandson mating is 12.5% inbred.
5. A calf from a 1st cousin mating is 6.25% inbred.

What effect does a large proportion of mickies have on inbreeding levels?
The potential effects on production are illustrated in the table below which summarises the results of a number of experiments conducted on inbreeding in beef herds.

<table>
<thead>
<tr>
<th>Production Character in Inbreeding</th>
<th>Fall in Production For Each 10% Rise Summarised</th>
<th>Number of Experiments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth Weight</td>
<td>0.02 kg</td>
<td>1</td>
</tr>
<tr>
<td>Weaning Weight</td>
<td>7.00 kg (range 4.3-9.7)</td>
<td>7</td>
</tr>
<tr>
<td>Yearling Weight</td>
<td>8.30 kg (range 5.5-11.1)</td>
<td>2</td>
</tr>
<tr>
<td>Calves Born per 100 Cows Joined</td>
<td>3.9 (range 0.0-9.0)</td>
<td>2</td>
</tr>
<tr>
<td>Calves Weaned per 100 Live Calves Born</td>
<td>10</td>
<td>1</td>
</tr>
</tbody>
</table>


Figure 13: Inbreeding Depression: Effects of Inbreeding on Beef Production

DESIGN OF HERD BREEDING PROGRAMME

The principles of design for breeding programmes are similar regardless of the purpose or type of programme.

There are two basic types:

- selection within a breed, and
- crossing of breeds.

Options to be considered for selection programmes include:

1. Closed Herd

   In this case the breeder produces all replacement bulls, selecting the best for use in the herd. This option is rarely used except by some stud breeders. The main reasons are:

   a) The bulls over the fence often look better.

   b) It is good public relations and often results in better returns if bulls from well known studs are purchased.

   c) Under extensive conditions bulls would have to be selected from a nucleus herd where characters were accurately measured. This is often not possible.

2. Breed some and purchase some replacement bulls.

   If artificial insemination is to be used in the NT to breed replacement bulls then it is likely to be in this combination.
Once again it is important to ensure that the bull(s) you choose for AI are proven to be superior to your own herd in the characters you wish to improve.

The bull replacement scheme outlined in this section is merely an illustration of what can be done and the associated costs. As individual producers vary in their requirement it is not possible to make recommendations about the number of breeders retained in the nucleus herd, selection intensity, etc. However don’t take on more than you can handle. In the first instance a nucleus herd of about 100 head is quite adequate and will give you the opportunity to assess your ability to implement a programme, future requirements in terms of organisation, labour and facilities and will give an indication as to whether or not it is an effective management tool.

The programme outlined below represents one option which could be considered. Whatever the requirements are it is essential that you sit down, define your objectives and draw up a flow chart on which to base the implementation phase.

The practical considerations associated with the flow chart in Diagram 12 below are as follows:

a) Cows are pregnancy tested 4-6 weeks prior to insemination. Non-pregnant, cycling, healthy animals are included in the programme. Cows with calves greater than 2 months of age can be included.

b) Cows are pregnancy tested 6-8 weeks after insemination. Non-pregnant animals should be noted and bulls released into the herd. Animals which do not produce a calf should be culled. The importance of numbered ear tags and accurate records is emphasised here.

c) Heifers as a result of AI can be used as replacements for the commercial herd or nucleus herd. If they are returned to the nucleus herd it is necessary to ensure that semen from a different bull is used to prevent inbreeding.

Preferably, any one bull’s semen should not be used for more than one season unless a period of 5-7 years has elapsed since it was first used.

d) Selection of replacement bulls. Bulls should be evaluated at weaning and again before the first mating (18-20 months). Scrotal circumference, liveweight, liveweight gain, frame score, physical defects, temperament etc. should be assessed. Research has shown that selection for the larger body weight is related to high fertility in bulls.

Diagram 11: Measuring Scrotal Circumference
Diagram 12: Herd Dynamics
BULL BREEDING UNIT — COST

Assumptions

1. 100 Cows.
2. 70% Calving from AI.
3. Inseminate over 2 cycles.
4. 1.5 straws used per cow.
5. Average cost of semen — $6.00 per straw.
6. Yards and holding paddocks are suitable.
7. 30% bulls are retained. With high selection intensity this could be decreased to as low at 10%.
8. Opportunity cost is the loss of income from bulls retained and not sold as steers.
9. Loss of income incurred through keeping 11 bulls for 2 years is compensated for by their sale after selection.

These costs and their relative importance will vary for individual producers and are affected by the organisation of the programme, ability of the inseminator and environmental influences. This example does not include a provision for capital investment that may be required to upgrade or build holding paddocks, yards etc. in the first instance. This is an important consideration and potentially a very expensive exercise and must be evaluated by the individual according to their situation and requirements.

<table>
<thead>
<tr>
<th>Costs</th>
<th>$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semen — $6.00 per straw</td>
<td>900</td>
</tr>
<tr>
<td>Extra Labour (1 man x 4 weeks)</td>
<td>1 200</td>
</tr>
<tr>
<td>Insemination (including drugs, ear tags etc.) $16.00 per cow</td>
<td>1 600</td>
</tr>
<tr>
<td>Opportunity cost — $150 each for 11 head retained as bull and not turned off as steers</td>
<td>1 650</td>
</tr>
<tr>
<td>TOTAL</td>
<td>$5 350</td>
</tr>
</tbody>
</table>

Bulls retained = 11
Cost/bull = $486
Cost per cows inseminated = $53.50

Cost per cow inseminated is considerably higher than that which can be achieved in the eastern states where $27.00 is an accepted estimate (Wacol).

It is now possible to compare the cost of AI bulls with that of purchased bulls. It should be noted here that this costs analysis is only applicable to a bull breeding unit.
<table>
<thead>
<tr>
<th>Purchases (freight not included)</th>
<th>Total</th>
<th>Al Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>11 Al Bulls @ $486</td>
<td>$5,350</td>
<td>Total: $150 per bull: $14</td>
</tr>
<tr>
<td>11 Bulls @ $500</td>
<td>$5,500</td>
<td>Total: $5,650 per bull: $514</td>
</tr>
<tr>
<td>11 Bulls @ $1,000</td>
<td>$11,000</td>
<td>Total: $11,150 per bull: $1,014</td>
</tr>
<tr>
<td>11 Bulls @ $1,500</td>
<td>$16,500</td>
<td>Total: $16,650 per bull: $1,513</td>
</tr>
<tr>
<td>11 Bulls @ $2,000</td>
<td>$22,000</td>
<td></td>
</tr>
</tbody>
</table>

The advantages of a bull breeding unit are:

1. Annual savings by not purchasing bull replacements from outside sources and therefore a relatively cheap way of upgrading a herd.

2. Ability to select the best animal within and for your environment and management system. In purchasing a bull from outside one takes a chance on how well he will perform in his new environment.

3. Ability to select animals of uniform age under uniform environmental and pasture conditions.

4. Selection pressure can be increased in the nucleus herd.

5. Ability to avoid purchasing infertile or low fertility bulls. Some researchers have estimated that up to 10% of all sale bulls are potentially or actually infertile.

The disadvantages include:

1. Rate of genetic improvement in the bull and heifer progeny will take much longer to show than the immediate savings.

2. For significant herd improvements to be achieved a long term programme must be planned and adhered to.

3. Physical restraints of the extensive environment require higher management intensity than elsewhere.

4. Greatly increased time and labour requirement for effective implementation of selection practices.

5. If unlicenced semen is used then it is possible that genetic defects which are not easily recognised will be passed on to successive generations.
RECORD KEEPING

It is a requirement of the *Artificial Breeding Act* (Regulation 18) that certain records be kept by inseminators.

RECORDS TO BE KEPT

1. A licensed inseminator shall keep a written record of:
   
a) The details of each batch of semen received or despatched by him, including the address of the sender or receiver of the semen, the identity of the donor sire, the batch number and the date of collection and the premises at which the semen was collected from the donor sire;

b) The details of inseminations performed by him, including the date of those inseminations, the identity of the stock, the name and address of the owner, the identity of the semen used and any information that is available on conception rate, including the number of services per conception;

c) The date and method of disposal of any semen not otherwise accounted for; and

d) The details of any semen collections performed by him outside a semen collection centre, including the date of collection, the name and address of the owner, the identity of the donor sires, the identity of each batch of semen, the number of doses of each batch and the use or destination of that semen.

2. Records made in accordance with this regulation shall not be destroyed until the expiration of 5 years after the date on which they are made.

3. Annual reports shall be forwarded to the Chief Inspector by a licensed inseminator and shall include:
   
a) A record of inseminations performed during the year in Form 10 in Schedule 1, a copy of which shall be forwarded to the centre from which the semen was received; and

b) A record of all imported semen received or despatched, in Form 6 in Schedule 1.

4. A licensed inseminator shall keep a record of all collections of unlicensed semen in Form 11 in Schedule 1 that are to be moved from the property of origin and shall forward such record to the Chief Inspector as soon as possible after the semen has been removed.
   
a) A herdsman inseminator's licence — entitles the holder to practice Artificial Insemination on his own stock or that of his employer only.

b) A commercial inseminator's licence — entitles the holder to carry out the Artificial Insemination of any stock and charge a fee for services.

Records have a number of uses for both the producer and those who enforce regulations.

1. Sire identification, progeny or performance testing.

2. Stud records.
<table>
<thead>
<tr>
<th>COW No.</th>
<th>DATE</th>
<th>DATE/TIME</th>
<th>SEMEN</th>
<th>NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FIRST</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>PROSTAGLANDIN INJECTION</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SECOND</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>PROSTAGLANDIN INJECTION</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>DATE/HEAT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>DETECTION</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>DATE/TIME</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>A.I.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>BULL</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Batching</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3. Records are required when application is made to breed societies for registration of progeny.

4. Aids for determining selection priorities and practices.

5. Accurate records ensure that semen and AI progeny are not used or sold indiscriminately.

The log presented in Figure 14 contains the information which should be recorded in an AI programme.

A note book should be ruled up in a similar manner so that records are kept together and not lost in the filing system in the back paddock. The field note book should contain information about infections, condition, lactational state, details on oestrus cycle and any other relevant comments.

REMEMBER: Any recording system should have the following properties:

1. Simplicity
2. Sufficiently accurate
3. Up to date at all times
4. Easy to retrieve information from.

Well maintained records may provide the information required to explain such phenomena as poor conception rates. They aid in the identification of poor breeders. In addition they allow the inseminator to analyse the results on the basis of data collected throughout the programme and may assist in planning future programmes.

**CONTROL OF ARTIFICIAL BREEDING**

In the Northern Territory artificial breeding of all stock is governed by the *Stock (Artificial Breeding) Act (1979)* and Regulations (1981).

The Act is administered by the Chief Inspector of Stock (who is also Chief Veterinary Officer or C.V.O.) and D.P.P. Veterinary Officers and Stock Inspectors who are also Inspectors under this Act.

The Act requires that semen for artificial breeding may come only from an Approved sire, that is a sire approved by the Chief Inspector of Stock.

The Act also controls the sale of semen, either imported into the Territory or collected locally. The Act requires that a laboratory used for preparing semen should be licensed and, to be licensed, the laboratory must, of course, be of a standard acceptable to the Chief Inspector. The person collecting the semen must also be approved by the Chief Inspector. He must keep records and report regularly to the Chief Inspector. He must label and store semen in a specified manner.

The person performing artificial insemination must be a registered veterinary surgeon or a person approved by the Chief Inspector, unless the inseminator is the owner of the stock being inseminated or has the owner's authority and is using only semen from the owner's own bulls.
REFERENCES


* Morris, C (1979) "GUIDELINES FOR BEEF CATTLE BREEDING" No. 1 in a series “What happens to other aspects of production when you select for heavier beef animals”.

GLOSSARY

Abdominal cavity: Space within the body occupied by the abdominal organs, eg stomach, intestines, liver etc.

Abortion: Premature expulsion of the calf.

Abortion storm: Many abortions occurring within a herd, usually within a short space of time.

Accessory sex glands: Prostate gland, seminal vesicles and bulbourethral glands. Together they produce seminal fluid.

Adrenal gland: An endocrine gland located posterior to the kidneys.

Adrenaline: A hormone produced by the adrenal gland.

Afterbirth: A 'lay' term for the placenta, or membranes of pregnancy.

Ampoule: A small glass container containing one dose of semen. No longer in common use.

Ampulla: A storage area for sperm, at the end of the vas deferens.

Anatomy: The science of the structures of the animal body.

Anoestrus: Failure to show signs of oestrus.

Anus: Outlet of the rectum.

Artificial vagina: Artificial device for the collection of semen.

Bladder: Structure for the storage of urine.

Broad ligament: Structure which supports the reproductive tract of the cow.

Brucellosis: One of the infertility diseases of cattle, sometimes called Contagious Abortion.

Bulbo-urethral glands: One of the accessory sex glands of the male.

Cane: Metal holder for ampoules.

Caruncles: Raised areas of mucous membrane on the pregnant uterus, to which the foetal membranes are attached.

Caudal: Towards the tail.

Cervix: Structure separating the vagina from the body of the uterus.

Cilia: Hair-like projections on certain types of cells. Found in the fallopian tubes.

Cleft: Opening between the labia of the vulva.

Clitoris: Structure in the cleft of the vulva. The homologue of the male penis.

Conception: Fertilization of the ovum.

Cone: Rubber attachment applied to the end of an artificial vagina.
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connector</td>
<td>Used to unite the syringe and pipette when inseminating with ampoules.</td>
</tr>
<tr>
<td>Contagious</td>
<td>Capable of being transmitted.</td>
</tr>
<tr>
<td>Cornua</td>
<td>Horns (of the uterus).</td>
</tr>
<tr>
<td>Corpus luteum</td>
<td>CL: Structure which develops on the ovary after rupture of the Graafian follicle. Produces the hormone progesterone.</td>
</tr>
<tr>
<td>Cotyledons</td>
<td>Areas of the foetal membranes which attach to the caruncles.</td>
</tr>
<tr>
<td>Cranial</td>
<td>Toward the head.</td>
</tr>
<tr>
<td>Density</td>
<td>An estimate of the concentration of spermatozoa in semen.</td>
</tr>
<tr>
<td>Detection</td>
<td>With reference to oestrus, finding cows in standing heat.</td>
</tr>
<tr>
<td>Dioestrus</td>
<td>Quiescent period of the oestrus cycle, between metoestrus and pro-oestrus.</td>
</tr>
<tr>
<td>Ejaculation</td>
<td>Expulsion of semen.</td>
</tr>
<tr>
<td>Electro-ejaculator</td>
<td>Machine used to stimulate ejaculation electrically.</td>
</tr>
<tr>
<td>Endocrine gland</td>
<td>Any gland which produces hormones.</td>
</tr>
<tr>
<td>Endometrium</td>
<td>Glandular lining of the uterus.</td>
</tr>
<tr>
<td>Endometritis</td>
<td>Inflammation of the endometrium.</td>
</tr>
<tr>
<td>Epididymis</td>
<td>Structure, closely allied to the testicle involved in the maturation and storage of spermatozoa.</td>
</tr>
<tr>
<td>External cremaster muscle</td>
<td>Associated in maintenance of optimum testicular temperatures.</td>
</tr>
<tr>
<td>External urethral orifice</td>
<td>Outlet of the urethra.</td>
</tr>
<tr>
<td>Fallopian tube</td>
<td>Oviduct, through which the ovum is transported from the ovary to the uterus.</td>
</tr>
<tr>
<td>Fertilization</td>
<td>Conception. The union of the ovum and spermatozoa.</td>
</tr>
<tr>
<td>Fimbriae</td>
<td>Serrated finger-like projections at the border of the infundibulum.</td>
</tr>
<tr>
<td>Follicle stimulating hormone</td>
<td>FSH. A hormone produced in the anterior pituitary gland that promotes the growth of the Graafian follicle, and oestrogen production.</td>
</tr>
<tr>
<td>Fornix vaginae</td>
<td>Blind space about the os of the cervix.</td>
</tr>
<tr>
<td>Gene</td>
<td>Basic unit of heredity.</td>
</tr>
<tr>
<td>Genital organs</td>
<td>Reproductive organs.</td>
</tr>
<tr>
<td>Genetics</td>
<td>The science of heredity.</td>
</tr>
<tr>
<td>Germinal epithelium</td>
<td>The outer layer of the ovary.</td>
</tr>
<tr>
<td>Gestation period</td>
<td>Period of pregnancy.</td>
</tr>
<tr>
<td>Glans penis</td>
<td>Sensitive tip of the penis.</td>
</tr>
<tr>
<td>Glycerol</td>
<td>Chemical substance added to semen during processing to protect the spermatozoa from cold shock.</td>
</tr>
<tr>
<td>Gonadotrophic hormones</td>
<td>FSH and LH produced in the anterior pituitary gland.</td>
</tr>
<tr>
<td>Graafian follicle</td>
<td>Mature follicle, on the surface of the ovary, containing the ovum.</td>
</tr>
<tr>
<td>Heat</td>
<td>Oestrus. The period during which a cow will stand to accept mounting or service.</td>
</tr>
<tr>
<td>Heritability</td>
<td>The degree to which a characteristic of an animal may be transmitted to an offspring.</td>
</tr>
<tr>
<td>Hormone</td>
<td>A chemical messenger. A substance produced in an endocrine gland, and carried in the blood to the target organ.</td>
</tr>
<tr>
<td>Hymen</td>
<td>A membrane occasionally found in the vagina and ruptured on first service in heifers.</td>
</tr>
<tr>
<td>Hypothalamus</td>
<td>An area of the brain associated with hormone control of the reproductive cycle.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>-----------------------</td>
<td>---------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Infundibulum</td>
<td>Cup shaped structure at the ovarian end of the fallopian tube.</td>
</tr>
<tr>
<td>Inguinal canal</td>
<td>Opening in the wall of the abdomen in the area of the groin. There are two such canals.</td>
</tr>
<tr>
<td>Inseminate</td>
<td>Introduction of semen.</td>
</tr>
<tr>
<td>InterCornuate ligament</td>
<td>Short ligament uniting the horns of the uterus for part of their length.</td>
</tr>
<tr>
<td>Labia</td>
<td>Lips (of the vulva).</td>
</tr>
<tr>
<td>Lactation</td>
<td>Secretion of milk.</td>
</tr>
<tr>
<td>Lateral</td>
<td>To the side.</td>
</tr>
<tr>
<td>Leptospirosis</td>
<td>One of the infertility diseases causing abortion.</td>
</tr>
<tr>
<td>Leydig cells</td>
<td>Cells in the testicular parenchyma producing testosterone.</td>
</tr>
<tr>
<td>Libido</td>
<td>Sexual drive.</td>
</tr>
<tr>
<td>Liner</td>
<td>Rubber tube, used to line an artificial vagina.</td>
</tr>
<tr>
<td>Lumen</td>
<td>Inner canal, or space.</td>
</tr>
<tr>
<td>Luteinising hormone</td>
<td>LH. A hormone of the anterior pituitary gland, which causes ovulation.</td>
</tr>
<tr>
<td>Luteolytic factor</td>
<td>A substance produced in the uterus which causes regression of the corpus luteum. It may be a prostaglandin.</td>
</tr>
<tr>
<td>Medial</td>
<td>Towards the middle.</td>
</tr>
<tr>
<td>Median septum</td>
<td>The internal division between the two parts of the scrotum.</td>
</tr>
<tr>
<td>Mediastinum testes</td>
<td>Strong fibrous stand within the parenchyma of the testes.</td>
</tr>
<tr>
<td>Mesometrium</td>
<td>Portion of the broad ligament supporting the uterus.</td>
</tr>
<tr>
<td>Mesosalpinx</td>
<td>Portion of the broad ligament supporting the fallopian tube.</td>
</tr>
<tr>
<td>Mesovarium</td>
<td>Portion of the broad ligament supporting the ovary.</td>
</tr>
<tr>
<td>Metoestrus</td>
<td>The period in the oestrus cycle immediately following oestrus.</td>
</tr>
<tr>
<td>Metritis</td>
<td>General inflammation of the uterus.</td>
</tr>
<tr>
<td>Morphology</td>
<td>Sharp or form.</td>
</tr>
<tr>
<td>Motility</td>
<td>Movement.</td>
</tr>
<tr>
<td>Mucus</td>
<td>Secretion produced from mucous membranes.</td>
</tr>
<tr>
<td>Neonatal</td>
<td>About the time of birth.</td>
</tr>
<tr>
<td>Oestrogen</td>
<td>The female sex hormone.</td>
</tr>
<tr>
<td>Oestrus</td>
<td>The period of sexual receptivity, often called standing heat.</td>
</tr>
<tr>
<td>Oogenesis</td>
<td>The process of ovum formation.</td>
</tr>
<tr>
<td>Os</td>
<td>The hole in the cervix projecting into the vagina.</td>
</tr>
<tr>
<td>Ovary</td>
<td>Female sex gland.</td>
</tr>
<tr>
<td>Oviduct</td>
<td>Fallopian tube.</td>
</tr>
<tr>
<td>Ovulation</td>
<td>The process of shedding of the ovum involving rupture of the Graafian follicle.</td>
</tr>
<tr>
<td>Ovum</td>
<td>Egg.</td>
</tr>
<tr>
<td>Oxytocin</td>
<td>Hormone stimulating smooth muscle contraction. Milk let-down hormone.</td>
</tr>
<tr>
<td>Palpate</td>
<td>To feel.</td>
</tr>
<tr>
<td>Pampiniform plexus</td>
<td>Coiled network of blood vessels, associated with maintenance of optimum testicular temperatures.</td>
</tr>
<tr>
<td>Parenchyma</td>
<td>The substance of the testicle.</td>
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<tr>
<td>Parturition</td>
<td>The process of giving birth.</td>
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<tr>
<td>Pelvic brim</td>
<td>Bony structure felt separating the abdominal and pelvic cavities.</td>
</tr>
<tr>
<td>Pelvic cavity</td>
<td>Space surrounded by pelvic bones.</td>
</tr>
<tr>
<td>Penis</td>
<td>Male organ of copulation.</td>
</tr>
<tr>
<td>Peritoneum</td>
<td>Smooth strong membrane lining the abdominal cavity.</td>
</tr>
<tr>
<td>Pipette</td>
<td>Plastic or glass tube used for inseminating with ampoules.</td>
</tr>
</tbody>
</table>
Pistolette: Inseminating gun.
Pituitary gland: Endocrine gland situated at the base of the brain, associated with control of the reproductive cycle.
Placenta: The uterine membranes, formed during pregnancy and closely attached to the lining of the uterus.
PMSG: Pregnant Mare Serum Gonadotrophin.
Polyspermy: The penetration of the ovum by more than one spermatozoa.
Prepuce: Skin-fold covering the glans penis.
PRID Progesterone Releasing Intravaginal Device.
Primary sex glands: The testicles.
Progesterone: Hormone produced by the corpus luteum.
Pro-oestrus: The period immediately preceding oestrus.
Prostate gland: One of the accessory sex glands in the male surrounding the neck of the bladder and the urethra.
Puberty: Age at which reproductive organs become functional.
Pyometron: Accumulation of pus in the uterus.
Rectum: Terminal portion of the intestinal tract.
Scrotal fascia: The ill-defined layer in the wall of the scrotum.
Scrotal raphe: Structure on the skin of the scrotum indicating the position of the median septum.
Scrotum: Sac containing the testicles.
Secondary sex glands: The epididymis, vas deferens, urethra and penis.
Semen: Fluid produced by the male containing spermatozoa and accessory fluid.
Seminal fluid: Accessory fluid.
Seminal vesicles: Paired organs being one of the accessory sex glands.
Semeniferous tubules: Microscopic structures within the testicle where spermatogenesis occurs.
Sigmoid flexure: ‘S’ shaped curve in the bull’s penis.
Spermatogenesis: The process of sperm formation.
Spermatozoa: Mature sperm cells.
Static holding time: Applies to a liquid nitrogen unit. It is the period of time for which a unit will keep semen safe, when not in use.
Sub-urethral diverticulum: Blind sac immediately caudal to the external urethral orifice in the cow.
Testicle: Primary sex organ of the male producing testosterone and spermatozoa.
Testosterone: The male sex hormone.
Trait: Characteristic.
Transverse annular folds: Oblique folds projecting into the lumen of the cervix.
Trichomoniasis: One of the infertility diseases, caused by a Protozoan organism.
Tunica albuginea: Fibrous outer layer of the testicle.
Tunica dartos: One of the layers of the scrotal wall, closely allied to the skin.
Tunica vaginalis: The inner lining layer of the scrotum, also covering the testicle.
Undulant fever: Severe disease in man caused by Brucella abortus.
Urethra: The outlet from the bladder in the female. Also carried semen in the male.
Utero-ovarian ligament: Ligament uniting the ovary and fallopian tube.
Uterus: The womb. Place of development of the foetus.
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
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</thead>
<tbody>
<tr>
<td>Vagina</td>
<td>Structure in the reproductive tract of the female, uniting the vulva and the cervix.</td>
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<tr>
<td>Vas deferens</td>
<td>One of the accessory sex organs, uniting the epididymis and the urethra.</td>
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<tr>
<td>Venereal</td>
<td>In relation to disease, capable of being transmitted at service.</td>
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<tr>
<td>Ventral</td>
<td>Towards the underline.</td>
</tr>
<tr>
<td>Vibriosis</td>
<td>One of the infertility diseases, producing return to service and delayed conception.</td>
</tr>
<tr>
<td>Vulva</td>
<td>External part of the female reproductive organs.</td>
</tr>
<tr>
<td>Working life</td>
<td>In relation to a liquid nitrogen unit, this is the period of time for which a unit will keep semen safe when inseminations are being carried out. Usually it is based on twice a day opening.</td>
</tr>
<tr>
<td>Yellow body</td>
<td>The corpus luteum.</td>
</tr>
</tbody>
</table>