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Reproduction in dairy cattle 1

What is important to know at the farm?

Bart Gietema

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Foreword

This guide on reproduction in dairy cattle is presented in two partner volumes:

Book I

Gives the basic facts of reproduction in dairy cattle. Facts which should be familiar to (modern) dairy farmers, dairy farm managers and extension workers dealing with dairy farming.

Book II

This part deals quite extensively with artificial insemination 'at work level' in a (sub)tropical environment.

It should be noted that in many places in the (sub)tropics 'extensive' dairy farming (as opposed to 'modern') may be the most common practice and in fact is the most economic way to keep cattle (see annex book I). The fact that this part pays so much attention to artificial insemination does not at all mean to say that it is a 'must' in dairy farming everywhere.

Acknowledgement

The text of both books has largely been adapted from texts originally prepared by Prof. Dr C.H.W. de Bois and Dr Uwland, formerly lecturers in the International Course on Dairy Cattle Husbandry of the International Agricultural Centre IAC in Wageningen, the Netherlands.

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1 Reproductive system and ovarian cycle

1.1 Introduction

Dairy cows are usually kept to produce milk and beef but the production of *offspring* is also important, because of its big influence on the milk and beef production on a farm.

After giving birth to a calf, a cow starts producing milk. The first weeks after calving milk production gradually increases. It reaches a peak one to two months after calving if all is well. After that milk production decreases. This goes on until the cow is dried off by the farmer or until the cow just stops producing. With low production cows, the latter can happen before the cow is 300 days in lactation; good cows, when not pregnant, can produce milk up till 400 or more days in lactation.

The *reproductive performance* is a measure of the number of offspring per cow per year; it has a great influence on the production of milk.

In this context, as a rule of thumb, a very good cow is a cow which produces **one calf every year**. A very good herd is a herd of which about 90% of the cows produce a calf every year. In the Netherlands such herds exist only where management is of high quality.

Unfortunately, in many places, too often reproduction is at a low level; this can be concluded from the long calving intervals and low conception rates.

Often, one of the major causes of low reproduction is poor herd management.

In the following sections and chapters, reproduction in cattle will be discussed, including aspects of artificial insemination, although the latter is the subject of Book II.

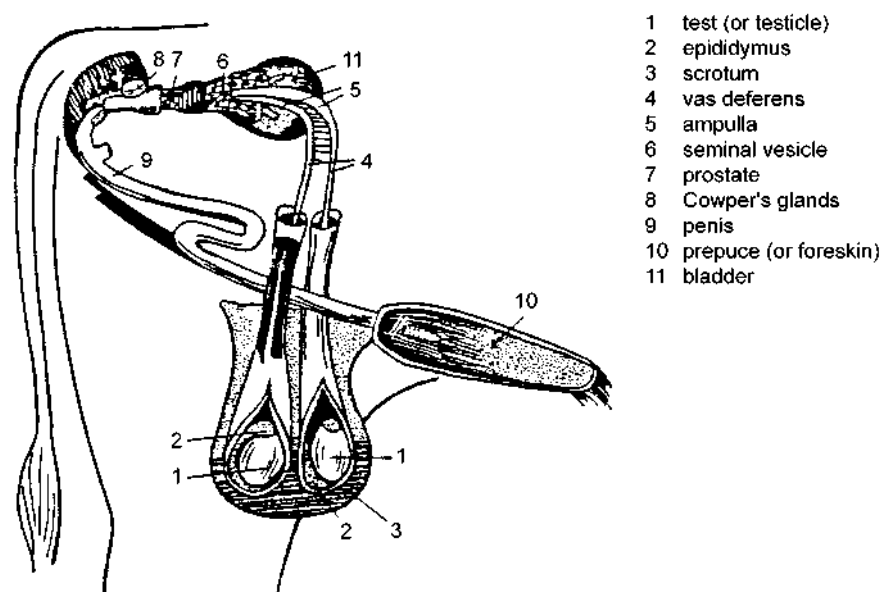


Figure 1: Reproductive tract of the bull

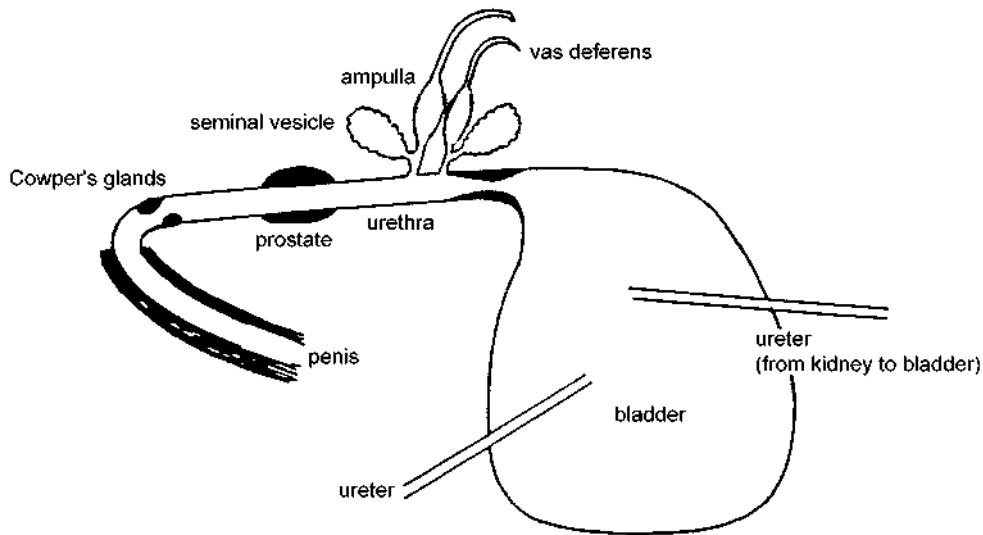


Figure 2: Reproductive tract of the bull

1.2 The reproductive tract of the bull

The male reproductive organs are the two testes (singular testis = testicle) and the epididymes (singular epididymis, meaning coil of conveying duct behind testicle); they are situated in the scrotum (bag enclosing the testicles). Furthermore the two vasa deferentia (singular vas deferens = spermatic duct), the seminal vesicles, the prostate gland, the Cowper's glands and the penis form part of the reproductive tract. The bladder, which collects and excretes the urine, is closely connected with the reproductive tract.

A *testicle* is made up of a semen producing part (more precisely spermatozoa = active fertilizing cells of male organism) and a hormone producing part. The semen producing part consists of a large number of small tubes that begin under the surface of the testicle and discharge into the epididymis. The total length of the small tubes is 400 to 500 metres. In these tubes the male cells are formed. A male cell consists of a more or less egg-shaped head, a short connecting piece and a long, mobile and wire-like tail.

The hormone producing part is situated between the semen producing tubes. With a microscope it is possible to detect clusters of cells, the so-called cells of Leydig, which produce the male sex hormones (testosterone). Hormones are a sort of messengers. They are produced in certain glands and transported by the bloodstream to their target organ. There they stimulate or inhibit certain processes. The hormones produced in the testicles have very important functions. They are of great influence on the development of the reproductive tract in young animals.

Later, when semen production starts, the hormones take care of the maturation of the male cells and bring about the sex drive (libido). Furthermore they are responsible for the development of the secondary sex characteristics. That is why a male animal has a different body conformation from a female animal. Bulls have greater muscle strength, bigger horns and show different behaviour than cows.

The testicles are situated in the *scrotum*. The main function of the scrotum is to assure the right temperature for male cell production. To produce viable male cells, the testicles must have a temperature that is 3 to 4 °C below body temperature. If the testicles get too cold, they are drawn closer against the body; the skin of the scrotum is wrinkled in this case. When it is very warm, the testicles hang further away from the body.

Scrotum temperature can also be controlled by the blood flow to the scrotum surface.

The *epididymes* are also situated in the scrotum. An epididymis forms a sort of coiled tube all along one side of a testicle. In these tubes the male cells are stored; at the same time there is a ripening process.

An epididymis can be divided into a head part, a body part and a tail part.

A *vas deferens* comes from the tail part of an epididymis and goes to the abdomen (belly). There it discharges into the urethra (duct through which urine is discharged from bladder). Just before the vasa deferentia discharge themselves into the urethra, they widen and form the so-called ampullae (singular ampulla).

The *ampullae* secrete a fluid that is mixed with the male cells when they leave the epididymes.

The *two seminal vesicles* are situated beyond the ampullae. These glands also secrete a fluid that is mixed with the semen.

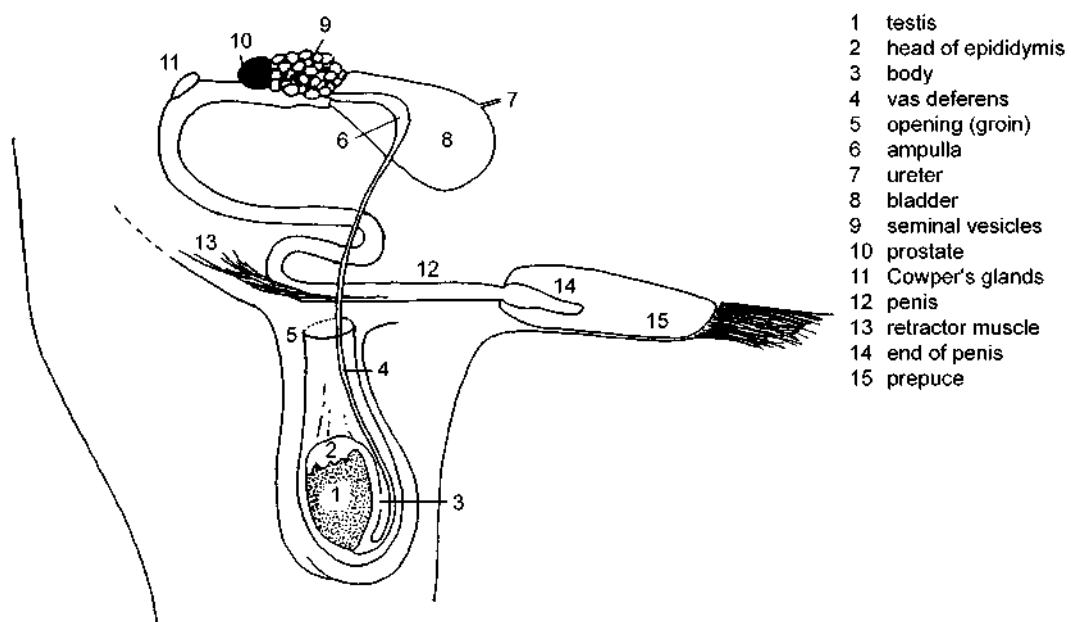


Figure 3: Again, the reproductive tract of the bull

In the urethra more fluid is added to the semen. This comes from glands, the *prostate gland and the Cowper's glands*.

When an animal ejaculates, the male cells pass from the epididymis through the vas deferens into the urethra. From there they pass into the *penis* and are excreted. On their way the male cells are mixed with fluids from the different glands.

The semen

Semen consists of male cells formed in the testicles and fluid from the so-called accessory male sex organs (ampullae, prostate, a.o.). About 5% is fluid with male cells from the epididymes.

The quantity of semen that is ejaculated by animals varies. A bull ejaculates 2 to 12 ml, a stallion 50 to 150 ml. In small ruminants such as the buck the amount of semen per ejaculation is 1 to 3 ml.

In semen of a bull and of small ruminants 500 million to 2000 million male cells per ml are found. The semen of stallions is less concentrated and contains 50 to 150 million male cells per ml.

Male cells can move. This can be seen under a microscope. The motility of these cells gives an indication of the quality of the semen. A good motility is desired.

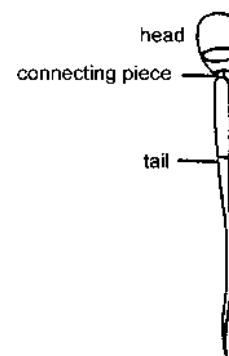


Figure 4: Male cell

Abnormalities in the male's reproductive tract

The absence of one or both testicles

Shortly before or after birth the testicles descend from the belly into the scrotum. Sometimes one or both testicles do not descend (horse; pig). If both testicles stay in the belly the animal will be completely sterile, except in cocks (birds) where this condition is normal. If only one testicle remains in the abdomen, the animal will be fertile. Such animals should not be used for breeding because this defect can be inherited by the offspring.

The absence of one or more accessory organs

This defect results in decreased fertility or total sterility. Genetic factors are involved.

One or both testicles or one or more accessory organs is/are too small

This condition generally results in the production of semen of low quality. It is also possible that there is hardly any semen production.

Insufficient erection of the bulls' penis

This is caused by mal-functioning of the retractor muscle. The S-formed curve in the penis is then not flattened completely, thus not making the penis come out enough.

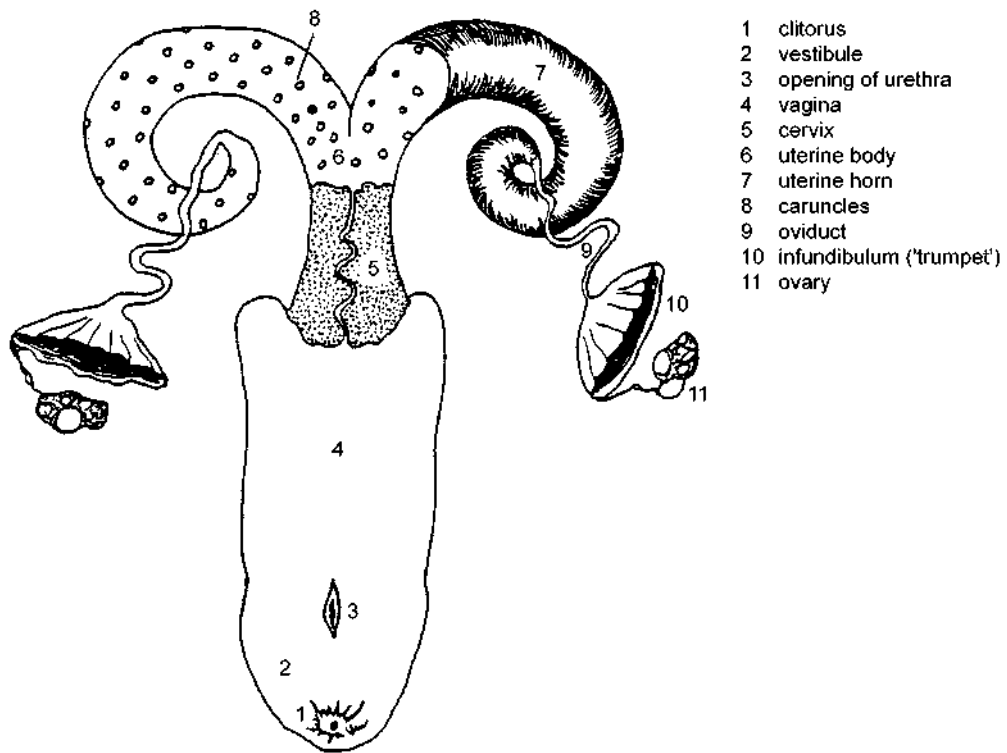
Castration and sterilization

When the testicles of an animal are removed (= castration), the animal becomes sterile and also loses its sex drive, while the (secondary) sex characteristics disappear partly or completely.

A male animal can also be *sterilized*, by cutting through the vasa deferentia (= vasectomy). In this case the testicles are not removed and the blood circulation in the testicles will continue.

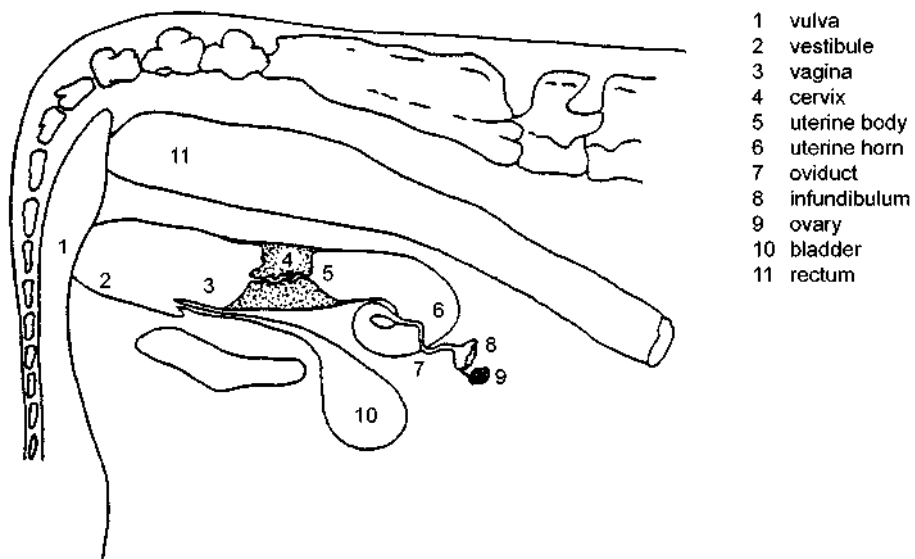
Male cell production will be inhibited this way, but the production of sex gland fluids and sex hormones can continue, and sex drive and secondary sex characteristics will not disappear.

Note that cutting through the vasa deferentia is in ordinary language often (wrongly) called 'castration'.



- 1 clitoris
- 2 vestibule
- 3 opening of urethra
- 4 vagina
- 5 cervix
- 6 uterine body
- 7 uterine horn
- 8 caruncles
- 9 oviduct
- 10 infundibulum ('trumpet')
- 11 ovary

Figure 5: Reproductive tract of the cow seen from above



- 1 vulva
- 2 vestibule
- 3 vagina
- 4 cervix
- 5 uterine body
- 6 uterine horn
- 7 oviduct
- 8 infundibulum
- 9 ovary
- 10 bladder
- 11 rectum

Figure 6: Reproductive tract of the cow seen from side

1.3 The reproductive tract of the cow

The cow (in general: the female mammalian animal) not only provides the egg essential for the beginning of a new animal, but also the environment in which the new individual will be conceived and nourished during the early part of its life.

To carry out these functions, the cow has primary and secondary organs of reproduction.

The *primary organs of reproduction* are the ovaries which produce ova (plural of ovum = egg) and female hormones.

The *secondary organs of reproduction* are the oviducts, uterus, cervix, vagina and vulva. The mammary gland (the udder of the cow) is sometimes referred to as an accessory organ of reproduction.

An inseminator should be very familiar with both the structure and the function of the organs of reproduction of the cow.

The *reproductive tract of the cow* lies in the pelvic cavity and consists of the vulva, vagina, cervix, uterus, the two oviducts and the ovaries plus supporting structures. The bladder discharges into the vagina.

The *vulva* is the external part of the reproductive tract and is the entrance to the vagina.

The vulva has two lips and a passage way of a few centimetres length. This passage is the *vestibule* of the vulva. In the ventral angle of the two lips is an organ of erectile tissue called the clitoris (which has no significance in artificial insemination).

Five to eight cm from the vulvar lips, on the floor of the vestibule, is the small opening of the *urethra* through which the urine from the bladder empties into the vulva.

Just beneath this opening is a small, blind pouch (suburethral diverticulum). The inseminator should be aware of these two openings because it is possible to direct the insemination pipette into one of these openings. To avoid this, the inseminator should direct the tip of the pipette upwards and forwards for the first centimetres.

In front of the urethral opening a slightly constricted area called the *hymen* may be present. This will not present any difficulty for the inseminator unless it is not perforated, a rare condition in cattle.

The *vagina* is continuous with the vulva and extends forward to the *cervix*. The vagina serves as passage for semen and urine; it is also the birth channel of the calf.

The vagina is a thin-walled, tough and elastic connective tissue organ. It is 20 to 30 cm long and tends to become longer with age and the number of calvings.

The vagina also functions as the copulatory organ; in natural mating the semen is deposited near the cervix.

The vagina is chemically acid because of lactic acid production by bacteria; this tends to prevent bacterial infections.

Urine (and air) may accumulate in the relatively large vaginal cavity if the walls are weak.

The *fornix* of the vagina is a blind pouch that encircles the projecting back part of the cervix in the cavity of the vagina.

This pouch may be troublesome for the inexperienced inseminator trying to introduce the pipette into the cervix. The pipette may bypass the external opening (os) of the cervix and be trapped in the fornix.

The *cervix* is a tough, muscular organ. It forms the connection between the vagina and the uterus. It is about 7 to 12 cm long and 2 to 5 cm wide, generally depending on age and number of calvings of the cow. The cervix is firmly closed. It opens only when the cow is calving and when the cow is on heat it opens a little.

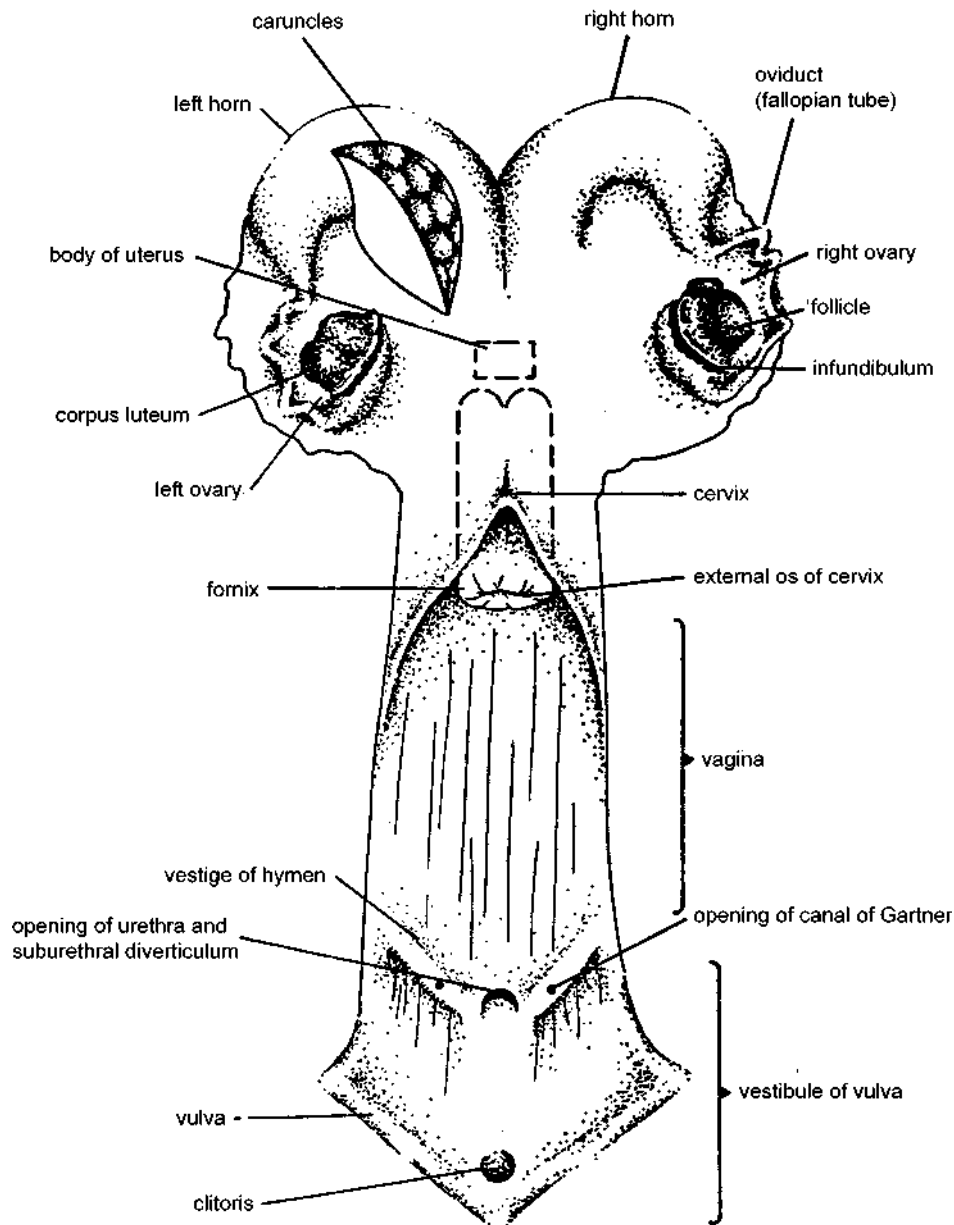


Figure 7:

The cervix observed through the vagina has a projected rosebud appearance, with an opening in the centre.

The cervix has several (three to five) thick folds or rings in its canal. Opposite folds overlap and form a narrow, spiral passage through the cervix. During oestrus ('heat') this passage is dilated and lubricated with mucus.

The inseminator, when trying to pass the pipette, may lodge it behind one of these annular rings and find the passage blocked. This problem occurs most often in virgin heifers with a small, underdeveloped cervix.

Fortunately the lining and walls of the cervix are thick and tough. This allows some manipulation or threading by the inseminator when the pipette is passed. However, any excessive pressure by the inseminator in forcing the pipette through the passage may cause haemorrhage (bleeding) and permanent damage to the cervix.

The *uterus* (womb) proper is composed of two parts, namely the uterine *body* and the uterine *horns*.

The *opening of the uterine body* is the target for semen deposition in artificial insemination. It is continuous with the anterior opening of the cervix and only about 2 cm in length.

The uterus has a thin, sensitive lining. If the insemination pipette is passed through the cervical canal and pressed too hard against the uterine wall, it may damage or perforate the wall and this will result in infection, sterility or even the death of the cow.

The uterine body divides into *two horns*.

The size of the horns depends on the age, the number of calvings and the length of time elapsed since the last calving. They are usually about 20 cm long in a virgin heifer and up to 40 cm long in older cows. The horns curve forward, downward, outward and then upward like the curled horns of a ram.

The horns are held in place by broad ligaments attached to the outside walls of the uterus.

The horns become quite firm and erect during oestrus and are then resistant to infection.

The uterine wall contains glands that secrete a substance called 'uterine milk' and a hormone.

The 'milk' nourishes the embryo between the time of conception and the time the foetal membranes begin to function. The hormone (a prostaglandin) causes regression of the corpus luteum if the cow does not become pregnant.

The wall of the uterus also has about 150 small, raised, button-like areas called *caruncles*.

These caruncles gradually develop after the egg has been fertilized. The foetal membranes are tightly attached to these caruncles; by means of these caruncles the cow passes nutrients on to the developing calf.

The two *oviducts* (so-called Fallopian tubes) are the tubular structures which carry the ovum from an ovary to the uterus. They are funnel-shaped at their ovarian end and tortuous; the distance from an ovary to the uterus is about 4 cm but an oviduct is about 20 cm long.

The funnel-shaped portion is the *infundibulum* of the oviduct which enfolds the ovary and traps the egg at the time of ovulation.

It takes about four days for an egg to traverse an oviduct so it is not present in the uterus until about four days after ovulation.

At the end of each of the two oviducts is an *ovary*. Their volume is about 8 to 10 cm³. They can usually be located (palpation) near the uterine horns to which they are attached by the ovarian ligament and the oviduct. This ligament is part of the broad ligament in which much of the reproductive tract lies.

The ovaries are very important for reproduction because they produce eggs and oestrogens (female hormones).

A few days before oestrus *follicles* begin to develop on the ovaries.

Follicles are fluctuating, fluid-filled, blister-like structures each containing an egg (egg follicles can be seen with the bare eye, in the slaughter house).

One of these follicles grows faster than the others and ruptures about 30 hours after the beginning of heat; this releases the egg into the infundibulum leaving an ovulation cavity.

Following the rupture of the follicle, a *corpus luteum* (CL or 'yellow body') forms in the ovulation cavity. This corpus luteum can be palpated by day-5 and it reaches its maximum size (20 to 30 mm) by day-13 of the oestrus cycle.

Most of the CL is embedded in the ovary but a small crown usually projects above the ovarian surface.

The CL produces the hormone *progesterone* which is essential for the maintenance of pregnancy.

Removal of the CL will cause abortion in the pregnant cow. This may be accompanied by bleeding and subsequent scarring which reduces the breeding potential of the cow.

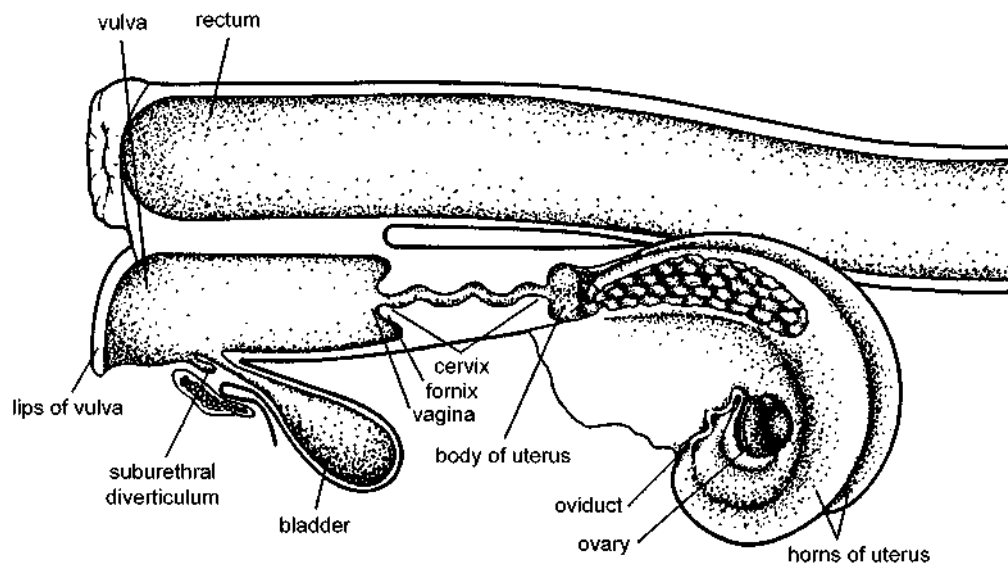


Figure 8:

1.4 The oestrus cycle of the cow

The **oestrus cycle** (also called ovarian cycle) is defined as the period from the beginning of one heat to the beginning of the next.

With the cow this period lasts on average **21** days.

At the beginning of this cycle the cow is unusually active and she is then sexually receptive; the cow is said to be 'in oestrus' or, more commonly, 'in heat'.

The time of first oestrus in the heifer varies from breed to breed and also depends on how well the heifer has been fed. Some well-fed dairy heifers may have their first oestrus when they are six months old. Some beef heifers may be eighteen months old before they come into heat, especially if they have not been fed properly.

The heat period lasts on average 18 hours with a range of 6 to 30 hours. About 90% of cows stay in heat from 10 to 24 hours. The most important part of the heat period is called the *standing heat period*. This is when the cow stands still when she is mounted by herd mates or a bull.

The ovaries of a cow contain numerous (many thousands) ova (= eggs), most of which are in resting stages. During each oestrus cycle several of these eggs become active. Fluid-filled cavities are formed, each containing an egg; they develop and enlarge and eventually form blister-like structures called follicles.

One of these follicles matures into a structure called *Graafian follicle*. The remaining follicles regress.

During heat the pituitary starts secreting LH (see below). Under the influence of LH, the Graafian follicle bursts open about 10 to 14 hours after the visible heat signs have disappeared and the egg is released.

The Graafian follicle has another, important function. The cells lining its wall produce 'female hormones' = oestrogens, which enter the blood and have profound effects on the behaviour and physiology of the female. In addition to heat inducement, the female hormones cause:

- growth and development of the female reproductive tract,
- growth of the muscle cells lining the uterus,
- increase of the blood supply throughout the tract (at the time of oestrus),
- contraction of uterine muscles (stimulation),
- production of mucus in the cervix and the vagina (stimulation),
- development and maintenance of secondary sex characteristics ('femininity').

Ovulation

The rupture of the Graafian follicle and the release of its egg is called *ovulation*. Ovulation takes place about 10-14 hours after the end of oestrus (= after the visible heat signs have disappeared). The egg is trapped in the funnel of the oviduct and carried into the canal of the oviduct. It is in this canal that fertilization takes place; in other words: where the egg meets the male cells.

Formation of corpus luteum (CL)

The cells which lined the cavity of the Graafian follicle continue to grow in size and to multiply in number until they fill the cavity; they now form the 'corpus luteum' CL (= 'yellow body'). The corpus luteum secretes *progesterone*, the 'pregnancy hormone'; the progesterone release starts 2 to 3 days after the end of the heat period. The preparation of the uterus for pregnancy, that was begun by oestrogen is continued by progesterone. If the cow conceives (becomes pregnant), the corpus luteum remains active and continues producing progesterone during the period of pregnancy. Progesterone has the following functions during pregnancy:

- it prevents the cow from coming on heat
- the function of the hormone oxytocin is blocked, thus preventing the start of labour
- it regulates the changes in the mucous membranes in the uterus
- it plays a role in the formation of udder tissue.

Oestrogens are produced by the placental membranes from about 3 to 4 months of pregnancy. These hormones are important for the growth of the foetus and for parturition.

If the cow has **not** become pregnant, the corpus luteum regresses (shrinks) and the uterus returns to its normal condition. At this time the pituitary starts releasing FSH again (see below) and a few days later the cow comes on heat once more. The cow is a 'poly-oestrus' animal, like the sow; this in contrast to the sheep (ewe), for instance.

A schematic review of the oestrus cycle is given below:

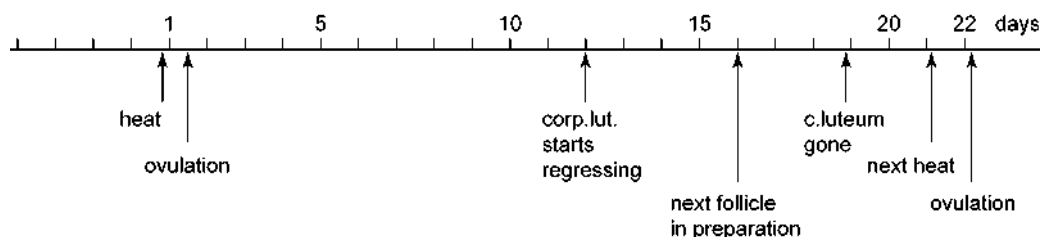


Figure 9: The oestrus cycle

Specific functions of progesterone are:

- 1 It stimulates growth and maintenance of the uterine mucosa and increases the blood supply to the uterus; this prepares the uterus for reception of the fertilized egg.
- 2 It causes secretion of 'uterine milk' by the uterine glands. Uterine milk supplies the nutrients for the fertilized egg until the placenta takes over this function (after about 45 days).
- 3 It inhibits contractions of uterine muscle and this makes it easier for the fertilized egg to attach itself to the lining of the uterus.

- 4 It causes the production of the cervical seal, a thick mucus 'plug' in the cervical canal which protects the embryo from infections.
- 5 It maintains pregnancy and prevents heat and ovulation in the cow.

Other organs involved in the oestrus cycle of the cow

Hypothalamus

The hypothalamus lies at the base of the brainstem. Among other things it monitors the levels of oestrogen and progesterone in the blood of the cow. As the levels of these hormones change, this causes the hypothalamus to produce either more or less of substances called *releasing factors*, which in their turn stimulate the master gland of the body which is the *pituitary gland*.

Pituitary

The pituitary gland is located in a pocket beneath the brain. It plays a vital role in the oestrus cycle by secreting hormones called *gonadotrophic hormones* which act on the ovary and cause puberty, ovulation, etc.

In the cow the hormones produced by the pituitary in the context of reproduction are:

- the 'follicle stimulating hormone' (FSH) which stimulates the growth of the follicle;
- the 'luteinizing hormone' (LH) which is involved in ovulation (i.e. rupture of the follicle, formation of the corpus luteum and secretion of progesterone by the corpus luteum) and in oestrogen production by the cells which line the follicle.

These pituitary hormones are in a delicate balance with the ovarian hormones and together they regulate the oestrus cycle.

The oestrus cycle of farm animals is still the subject of intensive research by scientists the world over; particularly its *regulation*.

The general picture of the *sequence of events* which takes place during the oestrus cycle of the cow is as follows:

- 1 'Releasing factors' (FSHRF) are released from the hypothalamus and cause the release of FSH from the pituitary gland. The FSH reaches the ovary and causes the development of a follicle.
- 2 The follicle on the ovary produces oestrogen which brings the cow into heat.
- 3 The level of oestrogen in the blood rises and this causes the hypothalamus to stop producing releasing factors. Without the stimulus of releasing factor, the pituitary no longer releases FSH.
- 4 The high level of oestrogen in the blood causes the hypothalamus to produce LH releasing factors (LHRF). These act on the pituitary and cause the release of LH. The correct balance of FSH and LH causes the follicle to rupture. Under the stimulus of LH a corpus luteum is formed which produces progesterone. If pregnancy does **not** occur, the corpus luteum reaches its maximum size on about the 13th day after oestrus and then begins to regress as a result of the production of luteolytic substances (prostaglandins) in the uterus.
- 5 In this case the level of progesterone in the blood decreases, thus permitting the hypothalamus to produce FSHRF which causes the pituitary to release FSH: this starts a new cycle.
- 6 But if the cow has become pregnant, the corpus luteum remains and enlarges. It becomes the corpus luteum of pregnancy and continues to secrete progesterone until the birth of the calf.

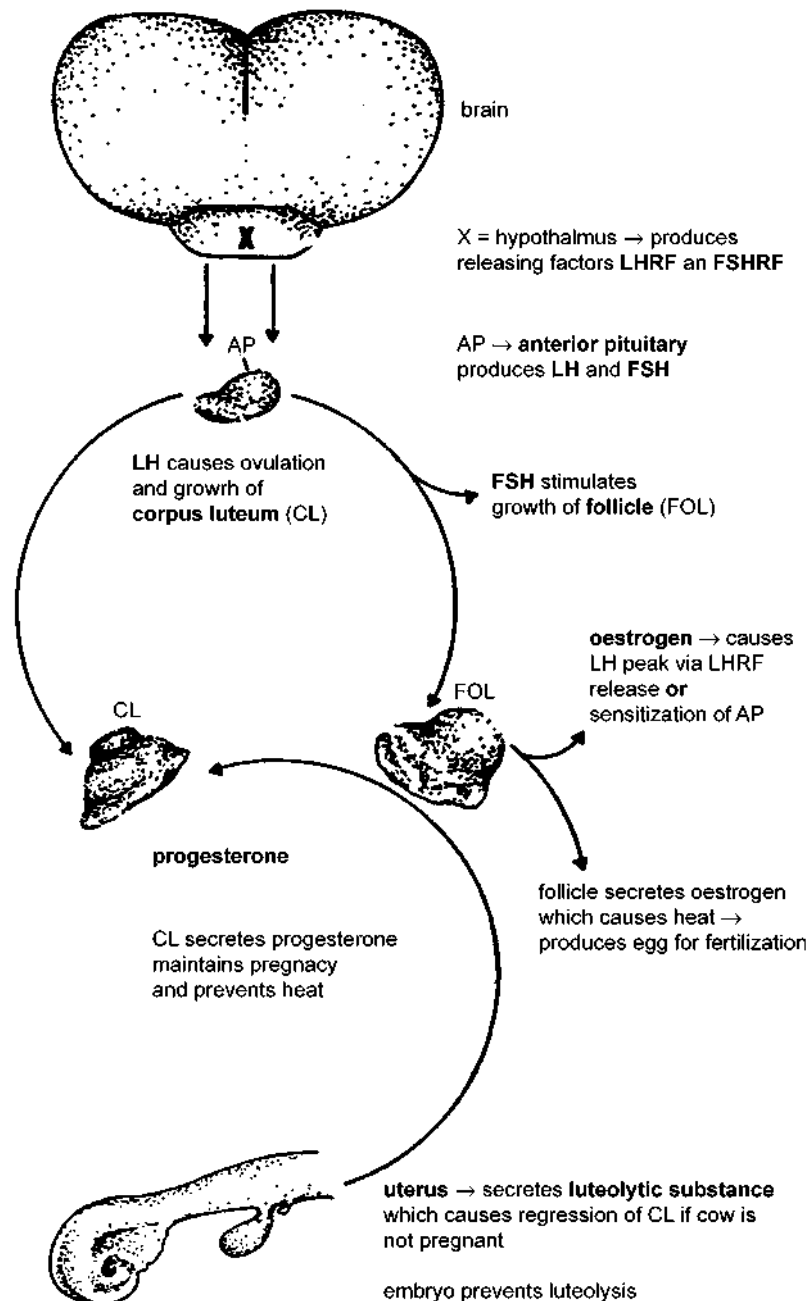


Figure 10:

Production of ova

A heifer is born with **all** the ova which she will have during her lifetime. Remember that in the bull male cells are formed *continually* (spermatogenesis).

During the lifetime of a cow approximately fifty ova are ovulated. At birth there are some 75,000 potential ova in each ovary of a calf. At one to three years of age there are about 21,000 ova remaining and later about 2,500 are still present.

This means that during the cow's lifetime many ova develop and then degenerate without ovulation; only a very few mature and then ovulate.

The maturation of the ovum involves many cell divisions (the same happens in male cell formation). However, one of the two cells resulting from each division of the ovum is relatively small and non-functional. Thus only **one** 'one-cellular organism' (the ovum) reaches maturity at each oestrus cycle. One of the cell divisions reduces the number of chromosomes to one-half the normal number.

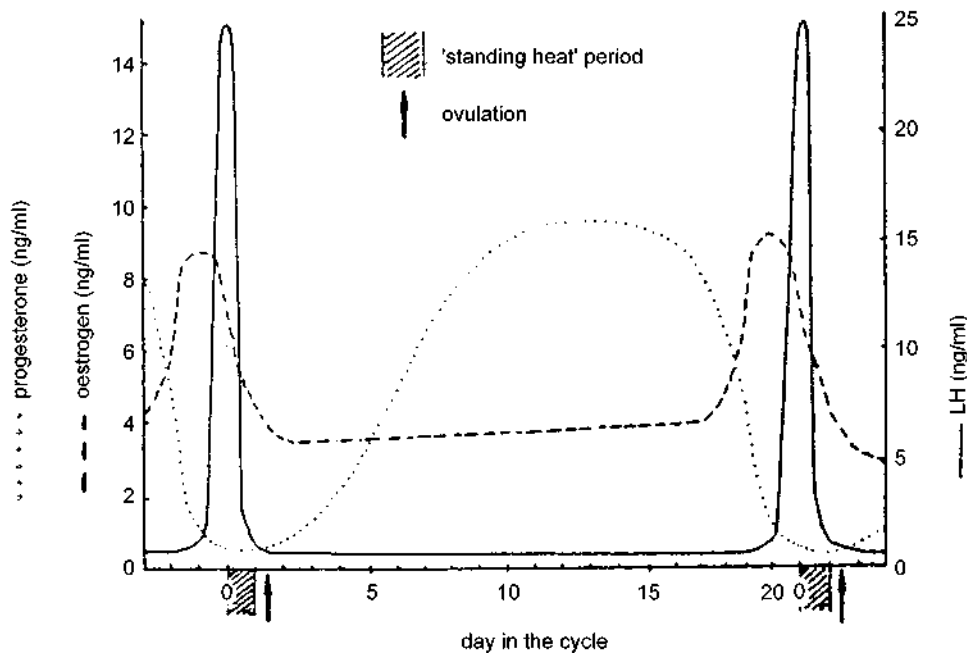


Figure 11: Hormone concentrations in the cow's blood during the oestrus cycle (no pregnancy)

Disturbances in the functioning of the ovaries:

- 'Silent heat'. The cow cycles normally and ovulation takes place but there are no heat signs. However, the cow is often blamed for the shortcomings of the herdsman who does not notice the (weak) heat signs!
- 'Cystic follicle'. The mature follicle does not burst open. In this case the production of oestrogen continues and in severe cases the cow is constantly on heat. A veterinarian can try to burst the follicle open.
- The corpus luteum does not regress although the cow is not pregnant. In this case the cow will not come on heat thus making the farmer believe that the cow is pregnant. A veterinarian can help.
- Pregnant cows are sometimes seen on heat. This is caused by insufficient progesterone production.
- Quite often embryos are lost during the early days of pregnancy or at about 25 days after conception ('early embryonic death').
- Abortion, because of infection of the placental membranes. For example, a brucellosis infection makes the placental membranes die off. In this case progesterone production stops and oxytocin is not blocked any more. This results in the expulsion of the foetus. Abortion can also have several other known or unknown causes.

For 'early embryonic death' and abortion, see Chapter 4.

2 Fertilization, gestation and birth

2.1 Fertilization

Fertilization means the *fusion (or union) of the ovum (egg) with a male cell*. The male cell actually penetrates the ovum. The fertilized ovum is the beginning of a new individual in which one-half of the chromosomes come from the sire (bull) and one-half from the dam (cow). The genetic material of the male cell and the egg have united to give the new individual the normal number of chromosomes needed for its development.

Fertilization normally takes place in the upper third of the oviduct.

When a bull serves a cow, millions of male cells are ejaculated in the vagina, close to the entrance of the cervix. Part of the cells move through the cervix into the uterus. Many cells have reached the oviduct within 6 to 7 hours after service.

In the uterus and oviduct, male cells can survive for about 20 hours.

Ovulation takes place 10 to 14 hours after the heat period. The mature egg can only survive for about 6 hours and therefore fertilization must take place within 6 hours after ovulation. Because of the limited time male cells can survive in the oviduct, service must not take place when the heat period starts. In this case it can be more than 24 hours later before ovulation takes place. An important rule is that *service or insemination should take place in the second half of the heat period*.

Male cells of some animal species must remain in the reproductive tract for a few hours before they are capable of fertilizing the egg. The changes that take place in the male cell during this time are termed *capacitation*. Although the need for capacitation has not been established for cattle, this may be another reason why semen needs to be inseminated a few hours before ovulation in order to obtain maximum fertility.

2.2 Gestation (pregnancy)

Early development; membranes

After fertilization, the fertilized egg splits into two cells. These two cells split up into four, these four into eight, etc. In the meantime the *embryo* is being moved through the oviduct into one of the uterine horns. In the cow, sheep and goat this process takes about 3 to 5 days, in the horse 8 to 10 days, after which the egg 'hatches' = attaches itself to the uterine wall for nutrition and further development. The cell division continues and after a few weeks the organs of the new animal are formed.

At four weeks the embryo in a cow has a size of about one cm. By the end of the second month it has developed into a complete miniature calf with a length of about eight cm. After three months it can be clearly recognized as a calf.

At about the 10th day after ovulation, the outer placental membrane (called *chorion*) begins to form and by the 17th day it extends throughout the length of the uterine horn. It is this membrane which is in close contact with the uterus of the cow and through which the embryo obtains its food.

By the 33rd to 35th day after ovulation the embryo is about 1 to 2 cm long and it is at this time that the embryo becomes attached to the wall of the uterus by means of the chorion. The attachment occurs by means of button-like structures which, on the chorion, have finger-like projections. These projections fit into grooves provided by button-like structures on the uterine wall. They are called *cotyledons* (caruncles). There are approximately 100 maternal cotyledons (on the wall of the uterus) which mesh with 100 foetal cotyledons (on the chorion).

As the foetus grows in the uterus the cotyledons become larger in order to provide for a greater flow of nutrients from the dam (the mother cow) to the foetus.

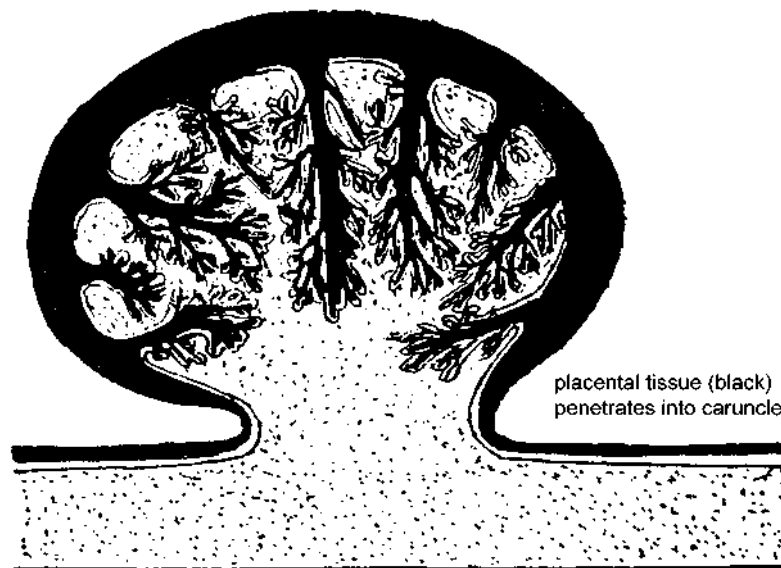


Figure 12: Caruncle on uterine wall

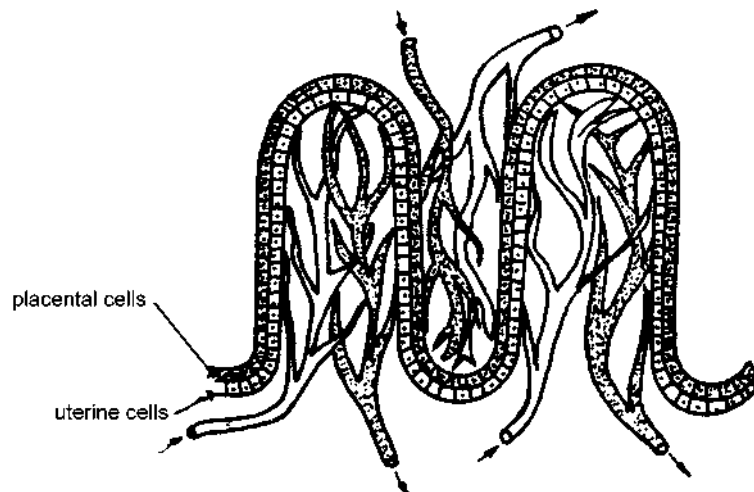


Figure 13: The blood vessels of mother and foetus are separated by just two cell layers

On about the 17th day another membrane forms which encircles the embryo. This membrane is called the *amnion*. Between the amnion and the embryo is the *amniotic fluid*. The embryo ‘floats freely’ in this fluid-filled sac and is thus cushioned against blows or injuries which the cow might receive.

The amniotic sac is known by cattlemen as the ‘water bag’.

Another membrane which develops from the growing foetus is the *allantois*. This membrane lies between the amnion and the chorion. It provides the means by which the foetus eliminates its waste products before it is born.

Thus the membranes have the following functions:

- protection of the foetus; also nutrition and the provision of oxygen,
- providing the connection between mother and foetus,
- excretion of metabolic wastes; secretion of oestrogen hormone,
- stretching of the birth channel during birth.

The membranes together make up the *placenta*. It is expelled soon after the calf is born. It is then commonly called 'afterbirth'.

Location

In heifers and in most normal, non-pregnant cows the reproductive organs are found within the pelvic cavity.

In older cows which have had several pregnancies, the organs usually extend partly over the brim of the pelvis and into the abdominal cavity.

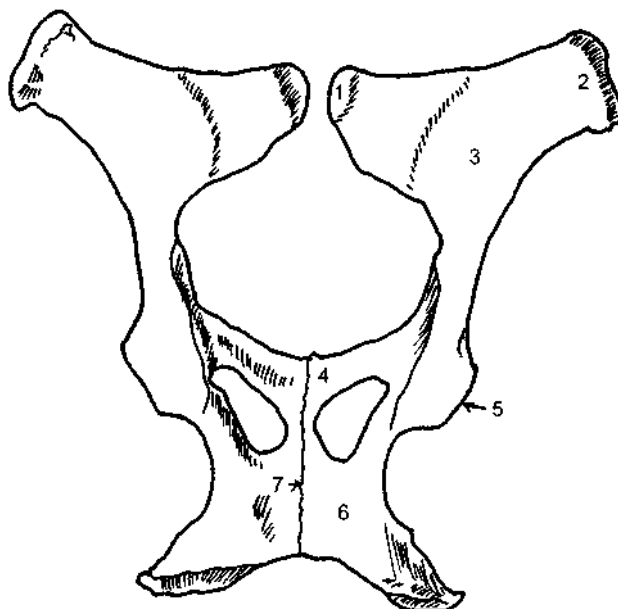


Figure 14: The pelvic bones with the (birth) channel

During the time of heat the reproductive organs are less relaxed than otherwise. In the heat period they take up less space in the pelvic cavity and the uterus is then quite firm when touched.

The broad ligaments of the uterus stretch as pregnancy advances and allow the uterus to go down into the abdominal cavity as the weight of the foetus increases.

Twins

Normally a cow has only one calf. Sometimes a twin is born. Twins may develop from one fertilized egg (identical or one-egg twins). In most cases, however, they develop from two fertilized eggs (fraternal or two-egg twins).

One-egg twins are genetically identical; therefore they have the same sex, appearance, characteristics and behaviour. Two-egg twins are not genetically identical. When they are of different sex, the female is almost always sterile (freemartin).

The duration of gestation is different for different animals:

- horse 48 weeks (11 months)
- cow 40 weeks (9 months and 9 days)
- sheep/goat 21 weeks (140 to 150 days)
- rabbit 30 - 31 days

Different breeds of cattle have a slightly different duration of gestation. The bull seems to have some influence as well.

Other factors that influence the duration of gestation are:

- sex and size of the foetus (males are carried longer than females),
- multiple pregnancy in a cow often causes an early birth,

➤ the age of the cow; first calving cows carry a few days shorter than older ones.

The development of the foetus is as follows:

Weight

When the cow is 4½ months pregnant, the foetus has about 10% of its birth weight.

At seven months, the foetus has reached about half of its birth weight. As from here onward its weight increases more rapidly.

Coat of hair

The foetus is viable when the body is completely covered with hair. This is the case when the cow is about 7½ months pregnant.

Length

7 weeks: size of a mouse (about 5 cm)

around 3 months: size of a rat (about 15 to 17 cm)

4 to 5 months: foetus has about 10% of its birth weight

6 months: the foetus has reached half the length of a newly born calf

7 months: the foetus has reached half of its birth weight

7½ months: the foetus is viable

9 months: the foetus is ready to be born, its length is 80 to 90 cm, its weight 30 to 55 kg (Zebu 20 to 25 kg)

2.3 Symptoms of pregnancy

No heat

The first sign that a cow might be pregnant is that she is not seen on heat any more. However, this is no guarantee because heats may have passed unnoticed and eventually pregnant cows may mount other cows.

Belly size

When the cow is more than four months pregnant, its belly size increases. This can be seen when standing behind the cow. The rumen pushes the pregnant uterus to the right.

The udder

Milk production in pregnant cows decreases faster than in non-pregnant cows.

During the dry period, about four weeks before calving, the udder starts swelling because of udder tissue development and fluid formation. In heifers the increase in udder size starts earlier.

Movement of the foetus

After the sixth month a milker, who puts his/her head against the right flank during milking, may notice the foetus moving.

2.4 The birth of the calf

As calving time draws near, the ligaments around the tailhead and pelvis of the mother cow relax and sink. The vulva swells and mucus discharge can be observed. The udder becomes rapidly bigger (fuller).

Shortly before birth the uterus begins to contract, mildly at first. This may go on for as long as 24 hours (on average about 4 hours) during which time the cow becomes increasingly restless.

The calf is pushed against the cervix causing it to open. During this time the calf assumes its birth position, lying on its belly with the forelegs extended and the head resting on them.

Powerful contractions of the uterus begin and these are supported by voluntary contractions of the belly muscles.

The result is that the calf is pushed through the birth channel, normally within a few hours.

As the calf's head passes through the vulva, it bends downwards. This helps the rest of the calf pass through the pelvis more easily.

In its normal birth position the calf assumes its smallest diameter. This is necessary to make the birth possible without too many difficulties.

As a rule the calf will be born within one hour after the forelegs begin to show in the vulva.

If the calf has not been born after an hour or two, an examination should be made. If the calf is in normal position, some assistance may be given by pulling with ropes that have been carefully attached to the forelegs.

Always pull downwards rather than straight out of the cow. Pull only when the cow strains and do it in a careful way.

Before giving assistance, clean water with a disinfectant should be used to wash the vulva and surrounding area. The person(s) giving the assistance should clean hands and arms thoroughly. Also the pulling ropes should be disinfected.

Abnormal dispositions of the calf occur sometimes. Veterinary assistance may then be needed.

Some abnormal dispositions are:

- only one front leg appears,
- the forelegs appear but without the head,
- the hindlegs appear first,
- the tail appears first.

In these cases the calf must usually be repositioned before it can be delivered.

Other abnormalities that can occur during calving include:

- the uterus contractions are not strong enough or cervix fails to dilate or area of bony pelvis is too small;
- the calf is too big for one reason or another; in this case surgery may finally be necessary to deliver the calf.

In normal delivery the foetal membranes rupture at about the time the forelegs pass the vulva.

Normally the calf is delivered free of the foetal membranes, which are still tightly attached to the placenta to assure a good oxygen supply to the calf during birth.

The umbilical cord (navel cord) usually breaks when the calf passes through the vulva. The calf must now start breathing since it can no longer obtain oxygen from the mother. Hence, after birth *oxygen* is the first requirement to make the calf survive. Make certain that the nostrils are free of membrane and fluids. Breathing can be stimulated by blowing air into the nose or by tickling the nasal cavity with a straw. This can make the calf sneeze which cleans the nostrils.

After birth the calf must receive *colostrum milk* as soon as possible (at least within two hours after birth).

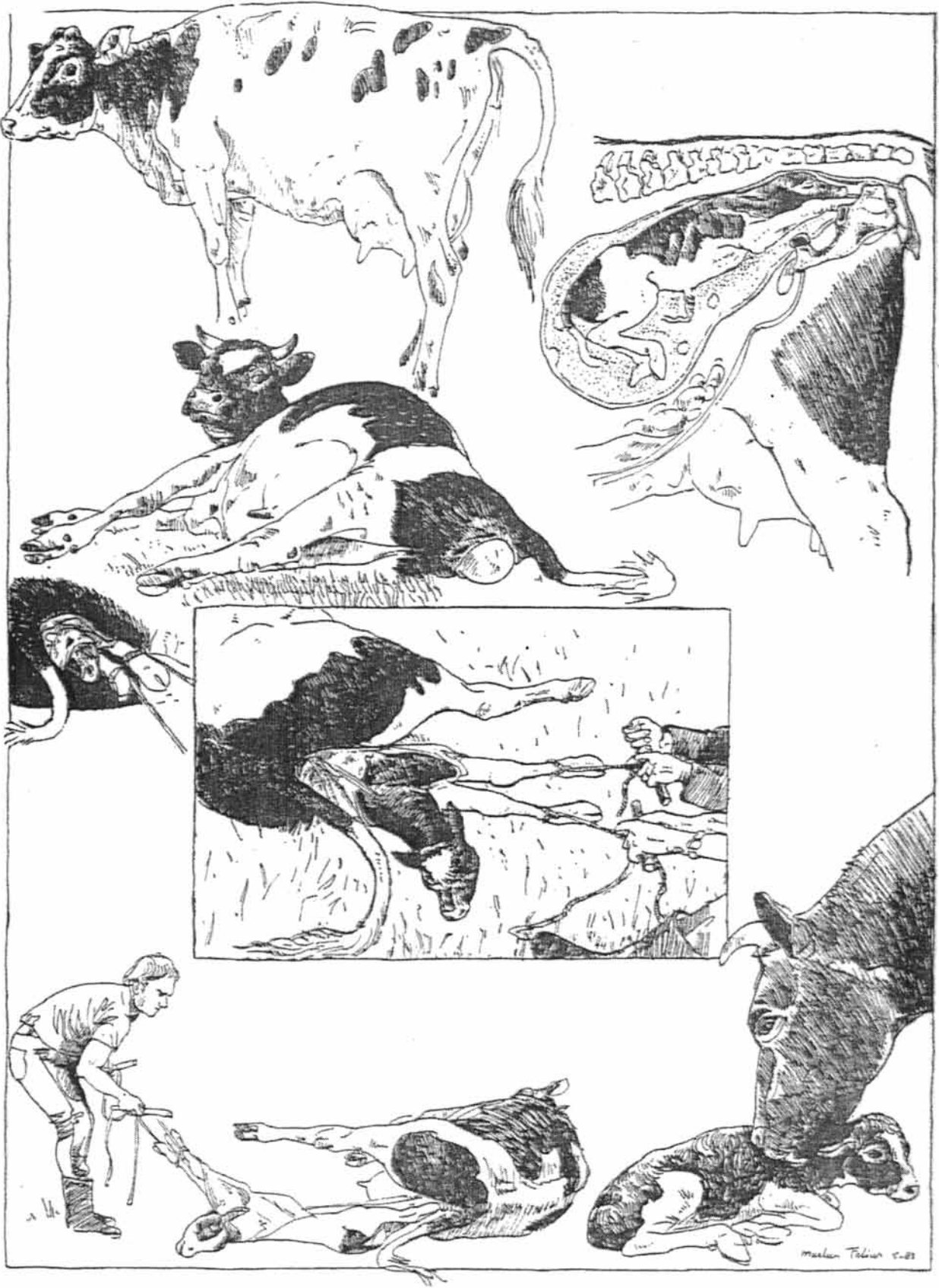


Figure 15: The birth of a calf (by Marleen Felius)

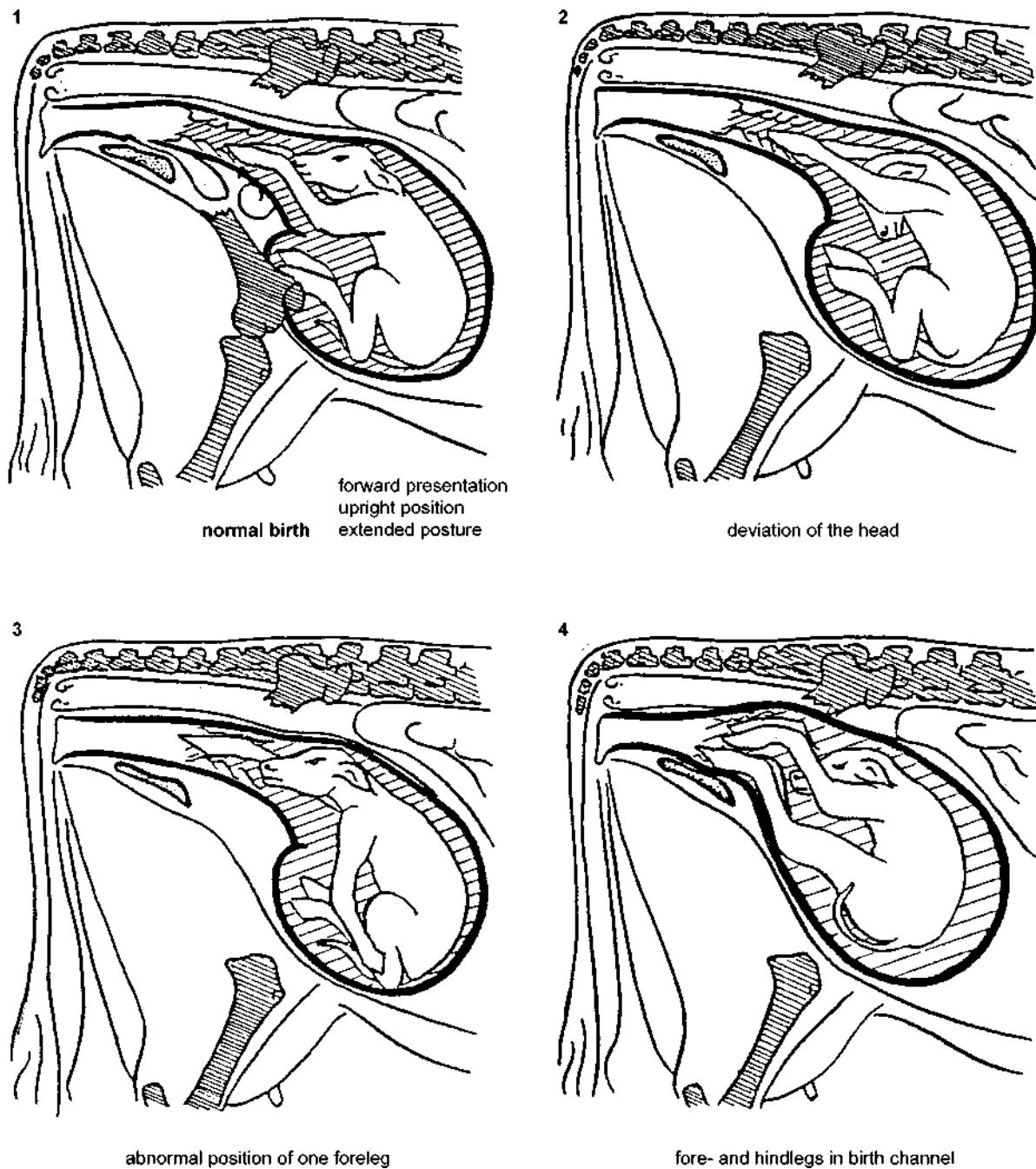


Figure 16: Abnormal positions of the calf in the uterus

After the calf is born, uterine contractions continue and they free the foetal membranes from the uterus and expel them. This is the *so-called afterbirth*. It should be disposed of as soon as it is expelled.

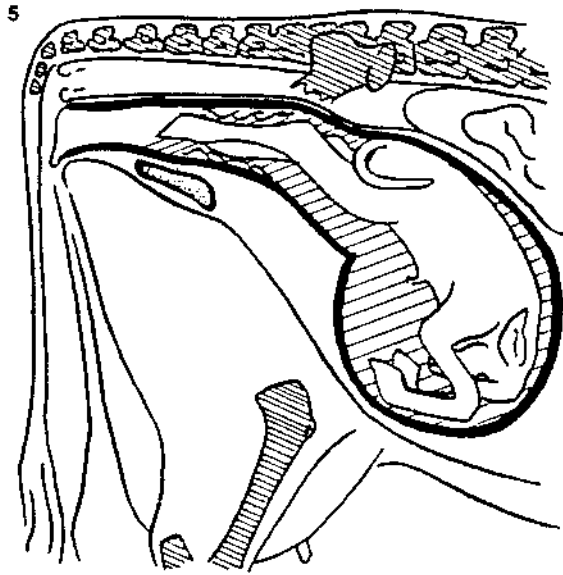
If the afterbirth is not expelled within 12 hours after parturition, it is considered *retained*.

When the afterbirth is retained and the cow sluggish, with a poor appetite, veterinary attention is needed.

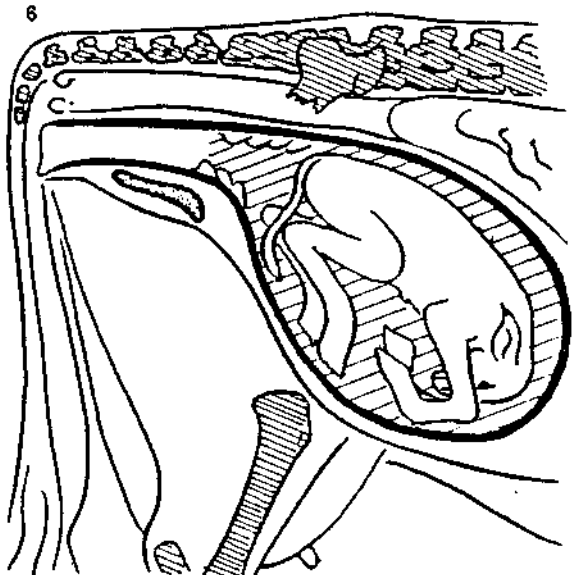
It is bad practice to remove the afterbirth with force. The afterbirth is never removed completely in this case and the uterus may be seriously damaged resulting in sterility of the cow.

Some fluid, containing blood and bits of tissue is usually found in the uterus after calving. This fluid is normally expelled during the first days after calving. This does not necessarily mean that there is an infection.

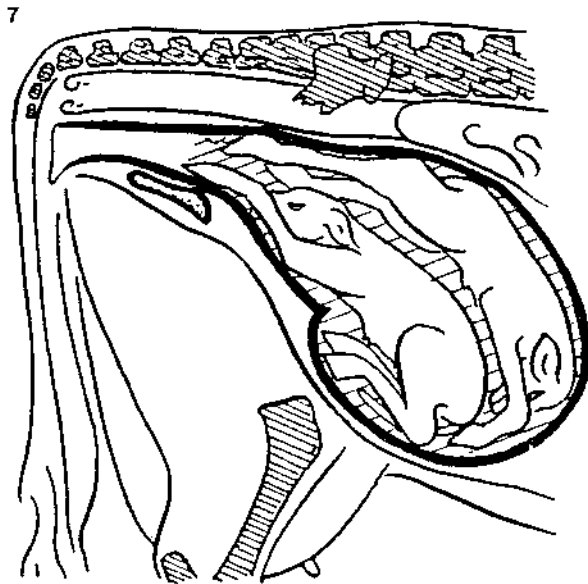
However, infections do occur after calving. A good indication of the beginning of an infection is the odour of the discharge. The bloody discharge that occurs the first days after calving should not have a strong, foul smell. If there is a foul smell and pus, prompt attention is needed.



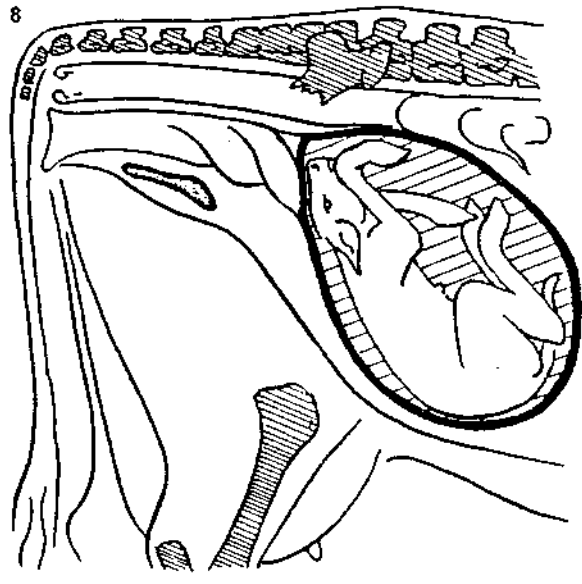
backward presentation
hindlegs extended



backward presentation
hindlegs flexed



twins



uterus has turned

Figure 17: Continuation

3 The reproductive performance of a dairy herd

3.1 The calving interval

The calving interval is the *period between two successive calvings of a normal cow*. The following is a schematic review of the calving interval, first simplified and then more complete on the next page.

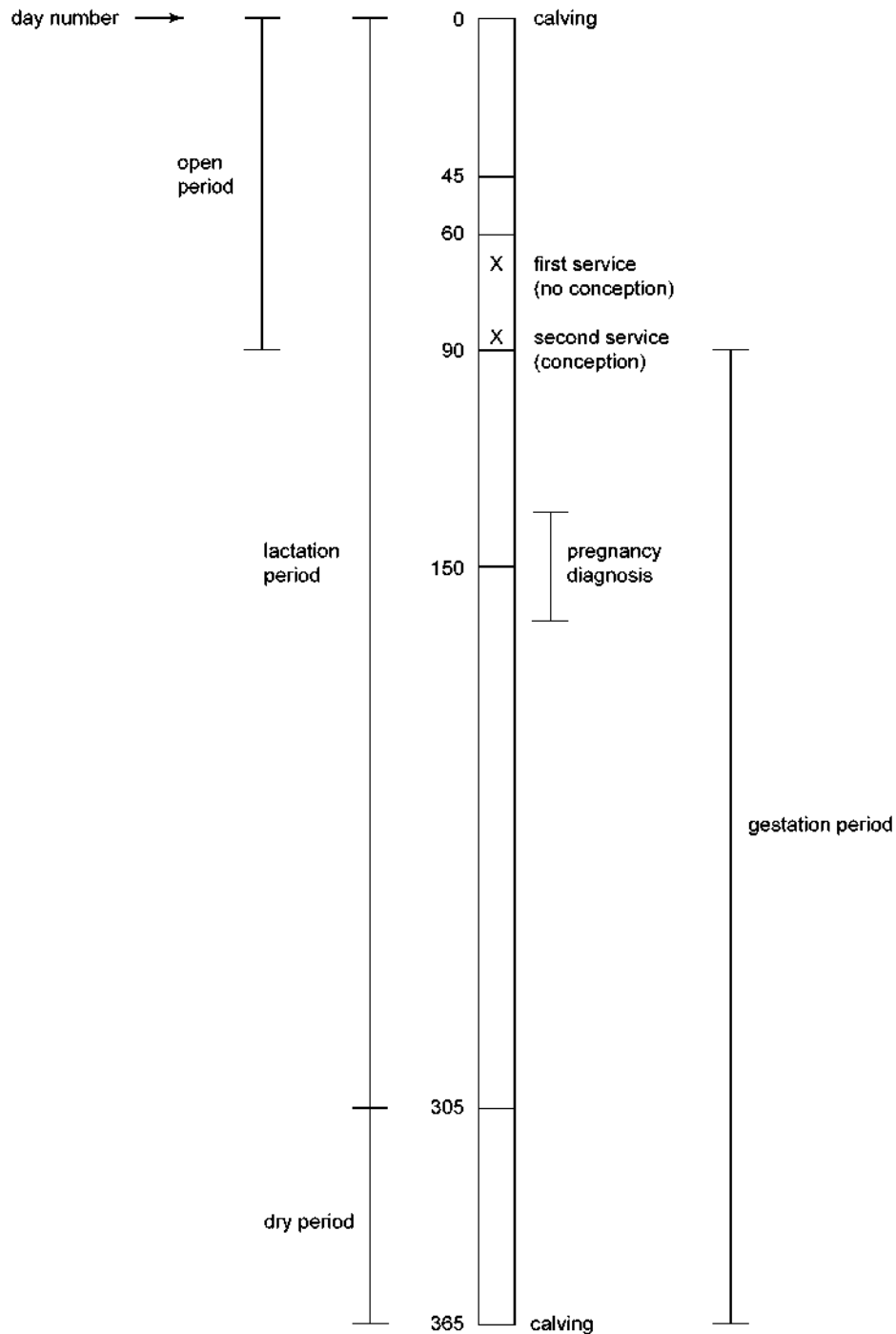


Figure 18:

Again, but more complete:

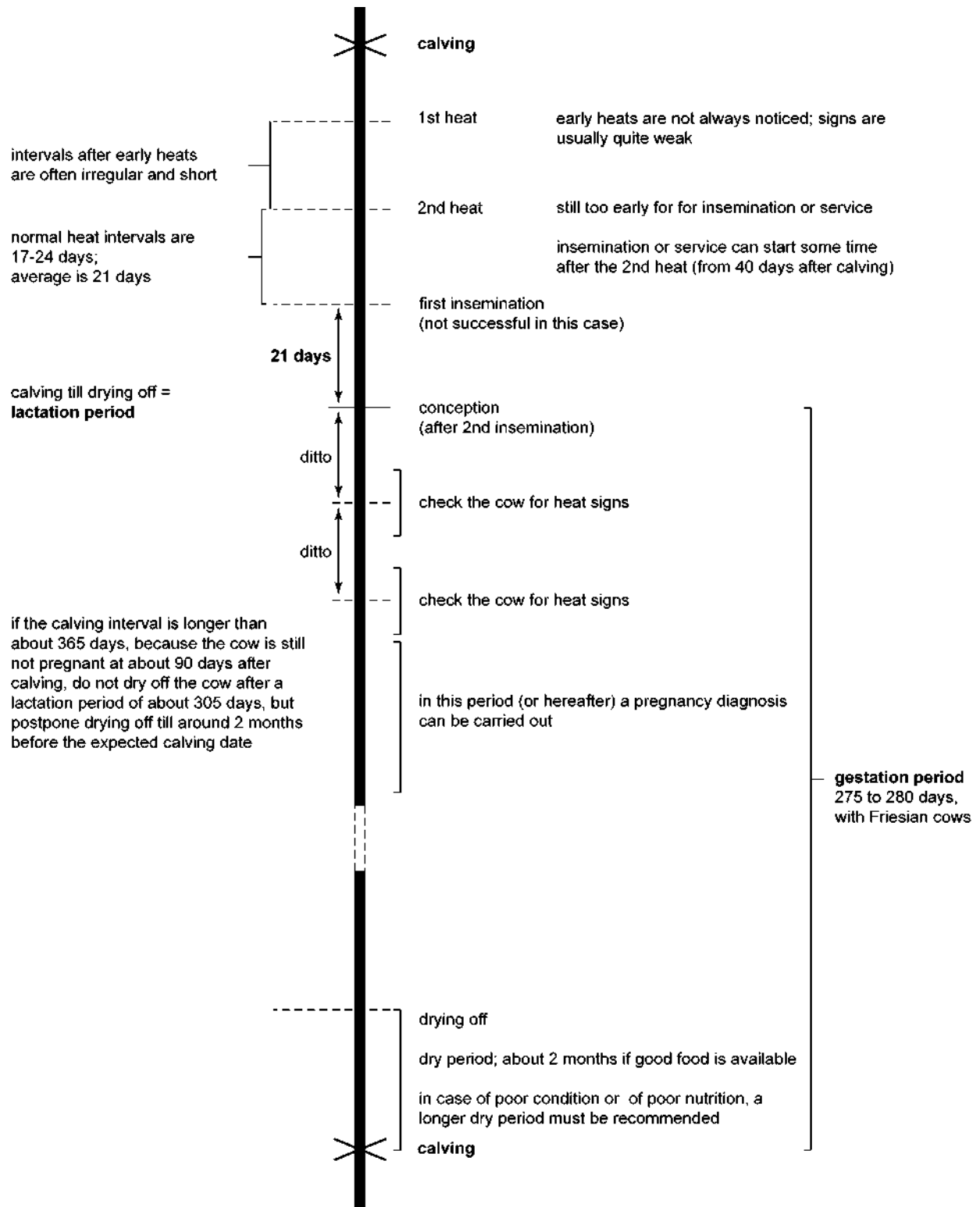


Figure 19:

3.2 The importance of good reproductive performance

A good reproductive performance means:

- higher average daily milk production,
- more calves per year,
- more opportunities for selection in the herd (better production).

The influence of the reproduction rate can be demonstrated with the following examples.

First example

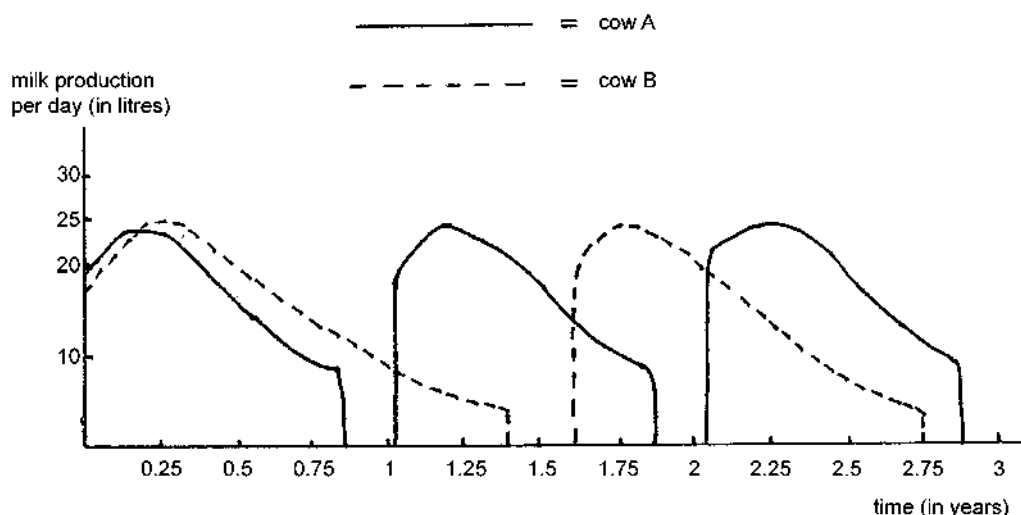


Figure 20: Influence of reproduction on milk production and on production of offspring

Cow A and cow B have the same genetic production potential. The only difference is their reproductive performance.

The illustration shows the lactation curves of both cows. In three years' time, cow A calves three times and cow B only twice.

The production per lactation of cow B is higher than that of cow A, but cow A has three lactations and cow B only two. The average milk production per day is highest for cow A.

Per lactation, cow A has a dry period of two months and cow B of three months. Besides producing more milk, cow A also produces one more calf.

In the Netherlands, optimum economic results are reached with calving intervals ranging from 350 to 390 days; for each farm the optimum interval can be calculated. When the calving interval becomes longer, the farmer's income decreases.

In the Netherlands, a prolongation of the calving interval by one day (beyond the optimum) means a loss of income of 1 to 2 US dollars. So, here a missed heat (a heat that is not noticed, while the cow could have been inseminated) costs 21 (days) x 1½ = about 30 US dollars.

Elsewhere losses will not be the same, as they depend on the price of milk, the value of a calf, feeding, housing and labour costs.

So, in other countries, under different circumstances, the 'optimum calving interval' may not be the same as that of the Netherlands. But everywhere it is worthwhile to try to find out what the optimum calving interval is.

In general, the shortest possible calving interval is likely to be the most advantageous.

Second example

Table 1: Influence of reproduction on production of offspring and replacement rate (selection)

	good reproduction & good calf rearing	poor reproduction & poor calf rearing
calving interval	1 year	1½ year
% of cows becoming pregnant	85%	65%
number of cows	1000	1000
calves born per year	85% of 1000 = 850	65% of 2/3 x 1000 = 433
stillborn calves	2% = 17	5% = 22
calves born alive	850 - 17 = 833	433 - 22 = 411
calf mortality 0 - 24 months	8% = 67	20% = 82
animals of 24 months	766	329
females	50% = 383	50% = 165
sterile heifers	5% = 19	10% = 16
pregnant heifers	364	149

Note: assuming that the average cow 'lasts' five years, each year 20% of the cows must be 'normally' replaced

Both examples give a clear idea of the importance of good reproduction.

3.3 Measuring the level of reproduction on a farm

Milk production and growth rate of calves can easily be measured by weighing and calculation.

To measure '*reproduction*' on a farm is more difficult and **requires constant, reliable record keeping**. With these records it should be possible to follow individual cows and calculate 'indicators', which give an idea about the level of reproduction of the herd as a whole. Important indicators are described in the following (a., b., etc.).

Age at first calving (heifers)

As long as a (future) cow is not producing, it costs money because it needs feed and care. For that reason *heifers should calve as early as possible*.

The age at first calving is influenced by:

- good calf rearing,
- good feeding after the rearing period,
- parasite control,
- the breed (Zebu or Bos taurus).

First service of heifers can take place when the animals have reached about 60% of mature body weight. Age and condition are also important.

With good feeding and good management, Friesian heifers in the Netherlands can be inseminated from the 15th month. This will result in a first calving age of 24 months at the earliest.

In the (sub)tropics, where circumstances may be less favourable, first service with Friesian heifers should be possible from 20 months, or when the heifer reaches about 325 kg live weight. 'Weight' would seem to be the better criterion, but is admittedly less easy to establish than age.

Calving interval

This is a well-known indicator of reproductive performance.

The calving interval can be divided into two periods: period of *calving to conception* (the non-pregnant period; also called 'open period' or 'service period') and the *pregnancy period* (the gestation period). The pregnancy period has a fixed duration of 275 to 285 days or some more, depending on the breed.

The *average calving interval* of a herd can easily be calculated and gives an impression of the reproductive performance of a herd.

In the event of too long calving intervals, the problems always lie in the first period (calving to conception). The causes of a long calving interval can often be traced by further analysis of the interval.

The calculated average calving interval does not include the cows who do not come in calf at all. Therefore the herd's reproduction is always lower than the average calving interval indicates.

First heat after calving

Normal, healthy cows come on heat within 40 days after calving. First heat can occur at about 10 days after calving already. First heats are not always observed.

In all cows, clearly visible heats should be noticed every 21 days (average), from 40 days after calving. If a cow is not seen on heat before or around 60 days after calving, there can be several reasons for this:

- the cow has been on heat, but this has not been noticed by the person who is responsible (poor heat detection). In most cases this is the main reason;
- the cow is not normal, it can have endometritis or cystic follicles;
- poor nutrition, especially insufficient amounts of protein and minerals, can cause problems (the cow is not cycling).

Practical advice: when a cow is not seen on heat around 60 days after calving, and when heat detection and feeding is good, a veterinarian should examine the cow for possible disorders of uterus and ovaries.

First insemination (or service) after calving

In order to obtain an average calving interval of 365 days, insemination (or service) should start as soon as possible after calving.

Normal, healthy cows can be inseminated or serviced successfully from 40 days after calving. With early inseminations or services, the conception rate is relatively low. However, this does not counteract what one gains in days of calving interval. Anyway, the first heat after 40 days from calving occurs around the 50th day on average; by that time the conception rate is already higher.

Practical advice: start inseminating normal cows from 40 days after calving. Low production cows may be inseminated earlier, high production may be inseminated a little later. The same applies to natural service. Be aware that insemination can only be successful in animals with a regular cycle (about 21 days).

Interval between two heats

The average interval between two heats lasts 21 days (17 to 24 days). So, when a cow does not conceive after insemination or service, 21 days later (on average) she comes on heat again. Shortly after calving (up till about six weeks), heat intervals are shorter and rather irregular.

When heat intervals of six or nine weeks (2 or 3 x 21 days) are observed, this generally means that one or two heats have been missed. However, it is often said in these cases that the cow has had silent heats, but this is most probably **not** true. Silent heats are extremely rare. In most cases the heat is simply missed (not noticed) by the person who is responsible, because it was a short heat or a heat with weak signs.

In the case of long and irregular insemination intervals (30, 50 or 90 days), embryonic deaths may have occurred.

Conception rate

After insemination of 100 cows, it will be noticed that after three weeks a certain number of cows comes on heat again meaning that they have not conceived.

The percentage of cows conceiving at first insemination after calving is a measure for the reproductive performance of a herd; it is called *conception rate after first insemination or service*. In the tropics it seems to be very difficult to obtain a higher rate than 50. In the Netherlands a rate of 60-70% can be obtained.

When the conception rate after first insemination in a herd is lower than 50, this would mean that reproduction is not what it should be in that herd.

Low conception rates can have the following causes:

- the cows are not inseminated at the right moment
- there is endometritis (uterus inflammation) caused by poor hygienic conditions
- poor semen quality
- wrong insemination techniques are applied
- the cows are not in good condition

Number of inseminations necessary to obtain pregnancy

Since not all cows become pregnant after a first insemination, more inseminations are necessary than there are cows in the herd.

Normally two inseminations per cow are required (average).

When the average is higher, reproduction is not what it should be.

The reasons for the average number of inseminations per cow being too high, are the same as mentioned under the heading 'conception rate'.

The average number of inseminations per cow on a farm can be influenced adversely by some poorly managed cows which only conceive after many inseminations.

Example: a herd with 100 cows (no bulling heifers)

100 first inseminations → 50 cows conceive
50 second inseminations → 20 cows conceive
30 third inseminations → 10 cows conceive
20 fourth inseminations → 6 cows conceive
14 fifth inseminations → 4 cows conceive

Ten cows are still not pregnant after five inseminations.

conception rate after 1st insemination is	$50/100 \times 100\%$	= 50%
„ 2nd „	$20/50 \times 100\%$	= 40%
„ 3rd „	$10/30 \times 100\%$	= 33%
„ 4th „	$6/20 \times 100\%$	= 30%
„ 5th „	$4/14 \times 100\%$	= 29%

In all, 90 cows become pregnant; so, the final conception rate (percentage of cows which do become pregnant) is **90%**.

In all $100 + 50 + 30 + 20 + 14 = 214$ inseminations have taken place.

An average of $214/90 = 2.38$ inseminations have been necessary per pregnant cow.

Ten cows did not conceive; they have had $10 \times 5 = 50$ inseminations.

The 90 cows which did conceive have had $214 - 50 = 164$ inseminations, which corresponds with 1.82 inseminations per pregnant cow.

From this example it can be learned that the number of inseminations per pregnancy can be calculated in **two** ways:

- total number of inseminations divided by the number of pregnant cows
- total number of inseminations of the cows which did conceive, divided by their number

Hence, always mention what is meant.

Note: In a healthy herd it may happen that conception rates do not decrease with repeated inseminations. So, from 2nd, 3rd and 4th inseminations also 50% may conceive.

Percentage of cows producing a calf

Sometimes it may be difficult to keep good reproduction records. For example, with a beef herd where a bull (or more bulls) are running with the cows, there are quite often no records dealing with reproduction. With such herds, the level of reproduction can be indicated by the number of calves born in the herd.

When in a herd of 100 cows 80 calves are born in one year, it means that about 80% of the cows produced a calf that year. Hence, the calving percentage is used as a measure of reproductive efficiency.

Note:

In the above calculations we have 'worked' with herds of 100 or even 1000 cows. This eased our calculations but has no other meaning.

The following page shows a table with reproduction data (from a dairy herd in North Africa).

Certain indicators have been calculated based on the data of the table.

In an instruction situation, the teacher should let the students calculate the indicators.

And, of course, calculating indicators of a herd known by teacher and students is also very instructive.

Of a total of 25 cows, 23 cows became pregnant again.

The average calving interval is $9044/23 = 393$ days.

First insemination is at $2331/25 = 93$ days after calving.

Conception rate after first insemination is $11/25 \times 100\% = 44\%$.

Total number of inseminations divided by the number of pregnant cows is $55/23 = 2.4$

Average number of inseminations of the cows which became pregnant is $46/23 = 2.0$

Reproduction on this farm is low. What could be the causes?

No. of the cow	previous calving date	heats (dates)			insemination or services (dates)					(expected) next calving date	interval (days) between				number of inseminations
		1st	2nd	3rd	1st	2nd	3rd	4th	5th		calving and 1st insemination	1st insemination and conception	calving and conception	calving interval	
1	11.10	20.10	30.10	20.11	11.12	-	-	-	-	11.9	61	-	61	335	1
2	10.11	10.1	30.1	-	20.2	3.4	21.4	1.6	13.8	-	102	-	-	-	5 sold 20.8
3	18.11	13.12	3.1	-	5.3	14.4	5.5	-	-	5.2	107	61	168	444	3
4	29.11	30.12	17.1	-	28.2	-	-	-	-	28.11	91	-	91	364	1
5	5.12	30.12	18.1	-	8.2	28.2	-	-	-	28.11	65	20	85	358	2
6	10.12	21.12	8.1	5.2	19.3	29.4	-	-	-	29.1	99	41	140	415	2
7	16.12	-	-	-	22.3	-	-	-	-	22.12	96	-	96	371	1
8	19.12	30.1	20.2	-	3.4	13.5	3.6	-	-	3.3	105	61	166	439	3
9	21.12	22.2	-	-	4.4	-	-	-	-	4.1	104	-	104	379	1
10	24.12	10.2	-	-	22.3	1.5	-	-	-	1.2	88	40	128	404	2
11	28.12	30.1	20.2	-	1.4	-	-	-	-	1.1	94	-	94	369	1
12	9.1	10.3	-	-	20.4	11.5	31.5	11.7	-	11.4	101	82	183	457	4
13	9.1	21.2	-	-	2.4	-	-	-	-	2.1	83	-	83	358	1
14	14.1	20.2	4.3	-	25.3	4.4	15.4	-	-	15.1	70	21	91	366	3
15	17.1	20.3	-	-	1.5	15.6	-	-	-	15.3	104	45	149	422	2
16	20.1	19.2	28.2	14.3	4.4	19.4	10.5	31.5	-	3.3	74	57	131	407	4
17	22.1	-	-	-	20.4	-	-	-	-	20.1	87	-	87	363	1
18	5.2	20.4	-	-	4.6	-	-	-	-	4.3	119	-	119	392	1
19	7.2	15.4	-	-	4.5	25.5	17.6	29.7	18.8	-	86	-	-	-	5 sold 8.9
20	9.2	28.2	4.4	-	16.5	-	-	-	-	16.2	96	-	96	372	1
21	15.2	20.4	-	-	31.5	10.7	-	-	-	10.4	105	40	145	419	2
22	9.3	-	-	-	10.6	30.6	20.7	29.8	20.9	20.6	93	102	195	468	5
23	20.3	15.4	30.4	-	11.6	-	-	-	-	11.3	83	-	83	356	1
24	18.4	20.6	-	-	29.7	5.8	20.8	-	-	20.5	102	22	124	397	3
25	20.5	14.7	-	-	13.9	-	-	-	-	13.6	116	-	116	389	1
											2331			9044	

Figure 21: Example of a herd production record; calculation of reproduction data

3.4 Causes of low reproduction rates

Low reproduction rates on a farm can have several causes; often it is a combination of factors which cause reproduction to be poor.

The causes can be divided into the following groups.

Poor management

Poor management has a rather **disastrous** effect on reproduction:

- Heat detection is poor. Without good heat detection, many heats are missed and this causes longer calving intervals. From the records (if well kept!) it can be learned whether heat detection is good or not. Heat intervals, or intervals between two inseminations or services, of around 42 or 63 days indicate that heats have been missed.
- Inseminating the cow at the wrong time. A cow should be inseminated during the last part of the heat period, or within six to eight hours after the end of the heat. If inseminations take place in the beginning of the heat or too late after the end of the heat, conception rates decline.
- First inseminations take place too late after calving. With normal, healthy cows and with good nutrition, the first insemination can take place from 40 days after calving. After 90 days after calving conception rates tend to decline.
- Often cows have to walk far before and after insemination. This raises the body temperature which has a quite negative effect on conception. A good advice would be to keep the cows quiet till about three days after insemination.
- Poor herd administration can have many negative effects. One of the effects is that 'problems' like cows not coming on heat, are not discovered on time. Without good records one is simply handling the cows 'like a blind man'.
- When there are reliable records they should also be used. Cows not coming on heat within 60 days after calving should be checked. If possible, six to eight weeks after the last insemination/service a pregnancy diagnosis should be carried out.

The environment

Good nutrition means sufficient energy, proteins, minerals and vitamins. Providing a balanced ration, according to the needs of the animal, does not only mean more milk, but also means a better reproductive performance. A better performance, by first calving at a younger age, by shorter calving intervals and by more cows coming in calf.

However, cows should not be over fed; then they become too fat and this has a negative effect on reproduction.

In many cases a mineral lick is advisable in addition to a normal ration, especially in the case of high production cows.

Lack of protein reduces reproduction (but too much protein causes diarrhoea and consequently also lowers fertility).

An important vitamin is vitamin A. Lack of vitamin A may be the cause when there is not enough green roughage (animals make vitamin A from carotene present in green roughage).

When there is lack of vitamin A, a premix with vitamin A should be used, or a lick which also contains vitamins.

Sometimes there are seasonal influences on reproduction when the cows mainly depend on grazing for their feeding.

Especially in the dry season there may be fertility problems because of low quality grazing.

Other seasonal influences may be *high temperatures and high humidity*. Heat detection may become very difficult. In case of high temperatures, heat detection should take place in the cooler periods of the day, with plenty of attention (see also following pages).

High temperatures and high humidity the year round (humid tropics!) : not so good for reproductive performance!

Diseases

Diseases affect (milk)production, but also fertility. Especially breeding diseases affect reproduction. When artificial insemination is applied in a correct way, the majority of the breeding diseases can be prevented. Do not use bulls which have a breeding disease as discussed earlier. Inflammation of the uterus (endometritis) also reduces reproduction. Endometritis can be largely prevented by taking hygienic measures around calving time as discussed before.

Hormonal disturbances

In individual cows hormonal disturbances can reduce fertility (problems with coming on heat or with conception).

Hormonal disturbances lead to inactive follicles or cystic follicles (corpus luteum persistence; the yellow body does not regress but continues producing progesterone). Or to follicles which do not rupture; in this case oestrogen is produced for a too long period. Some of these problems can be dealt with by a veterinarian.

Hormonal disturbances are in most cases individual cow problems. Hormonal problems are generally **not** the cause of an overall low reproduction rate on a farm.

Other influences

A low reproduction rate can also be caused by:

- The bulls which are used.
Some bulls produce semen that is not very fertile. This can be detected with the aid of a microscope. Only bulls with approved fertile semen should be used.
- Low quality semen.
When semen is not correctly conserved, or when it is not correctly treated, many of the male cells die off. Not only the freezing procedure but also the *thawing procedure* by the inseminator is critical in this respect.
- Wrong insemination techniques.
These can be overcome by better training of the inseminators. However, not every one can become a good inseminator by training only. The inseminator's attitude towards a cow and the way he approaches the animal are very important.
Rough handling of cows before, during and after insemination can be a cause of a low reproduction rate.

Conclusion

Reproduction problems are mainly caused *by poor management and by poor nutrition*. Therefore a low reproduction level on a particular farm is most probably only for a small part caused by the cows themselves. The influence of the farm's management is much bigger.

Often the reproduction rate is a *measure for the quality* of the management on a farm.

Remember that the reproductive performance of a dairy herd is the most important single factor affecting its profitability!!

3.5 Measures to improve the reproductive performance of a herd

Identification of the cows

Especially on larger farms it is a **must** to have a possibility to identify all cows in an easy way.

Heat detection and insemination

A first basic necessity for a good reproductive performance is proper heat detection. When cows are not seen on heat, they are not inseminated.

Signs of heat:

- the cow becomes restless, sometimes separating herself from the rest of the herd, walking along fences to seek a bull,
- the cow moos in order to attract a bull (*Bos taurus*; the Zebu does not do this),
- the cow excites other cows and **stands** to allow them to mount her; **standing** is the only reliable practical test of heat,
- signs that the cow has been mounted by others, because she has mud on her flanks, bare patches of skin on the hock or the pin bones, ruffled hair on the back or a hollow back,
- the lips of the vulva turn red and are somewhat swollen,
- there is a discharge of clear, thin mucus hanging from the vulva or adhering to the tail.

These signs may not all occur or be noticed simultaneously, but usually some at least are noticed.

It is important to detect a heat because if undetected, the cow will (again) not be served/inseminated and the calving interval will be longer.

It is advisable to check the cows three times per day; at milking time (2x) and during the dark hours (1x), preferably at times when cows are normally resting, so just before milking.

The length of the heat period in tropical countries appears to be shorter than in Europe; on average it lasts about 11 hours in the tropics, against 21 hours in Europe.

One of the causes of a low conception rate is *a wrong insemination moment*.

Insemination should take place in the last half of the heat period or up till 6 to 8 hours after the end of the heat.

Signs of heat

Since there is variation in heat duration, it is important to know when the heat started.

To get an idea about the start, it is necessary to carry out regular and proper heat checks. When a cow is silent at ten o'clock in the evening and is seen active at five o'clock in the morning, the heat period started during the night. This cow can be inseminated successfully towards the end of the morning or early in the afternoon.

When a cow is silent around five o'clock in the morning and starts to come on heat around nine o'clock, it is not advisable to inseminate the cow early in the afternoon; it is better to wait till the end of the afternoon or the first part of the night.

Often the inseminator is not present to do inseminations at the most appropriate moment. The following is a piece of practical advice. The cows seen on heat up till or around six to seven o'clock in the morning, can be inseminated the same day, in the morning (this in case the inseminator is coming only in the morning). The cows seen on heat after seven o'clock in the morning, should then wait till the following morning.

For good results, it is absolutely necessary that the inseminator *can come any day*, or that the farmer can on any day go to a place where he can have his/her cow inseminated.

Waiting one day or more after the end of the heat, reduces the conception rate up to zero.

If the inseminator is not available every day, it may be advisable to keep a breeding bull (if possible). When the inseminator does not come, the bull can serve the cow that is on heat.

There is one important difference, however, between artificial insemination and natural service by a bull. Insemination can still be done after the end of the 'standing heat'; natural service must be done during 'standing heat'; after that period natural service is hardly possible.

Stress

Proper handling of the cow prior to, during and immediately after mating or insemination are important. Things that should be avoided are : walking long distances, mishandling, shouting, sudden movements, non-routine events for cows and poor milking techniques.

In order to overcome the effect of heat stress on reproduction (in climates with a hot season), especially at the time of conception, seasonal breeding may be necessary; the cool season generally creates a better climatic environment for conception and implantation of the embryo.

Prevention of endometritis

Endometritis is an infectious inflammation of the uterus caused by bacteria (see page 49).

Endometritis often causes problems especially where there are (many) cows confined in small, (dirty) places for a long time. This is the case with zero grazing and permanent housing of dairy cows.

Normally a cow can only be infected during or shortly after calving. During calving and the first days thereafter, the cervix is open and bacteria can enter the uterus. Especially just after calving, the uterus is very vulnerable because there are many wounds in the uterine wall due to the rupture of the after-birth (placenta) from the uterine wall.

Where cows are confined, *good endometritis prevention* can be achieved by providing a clean environment, especially during and after calving. This can be done in the following way.

Separate the cow from the herd a few days before calving and bring her to a special calving pen. This pen must be cleaned (and disinfected) before the cow is brought in.

Just before calving, the hind part of the cow (the area around the vulva and the tail) should be washed and disinfected. Also the hands (fingernails!) of the helpers and the pulling ropes should be cleaned and disinfected.

If possible, the cow should stay in this calving pen for two to three days at least or, in the case of a retained afterbirth, till the afterbirth has come out. After this the cow can go back to the herd.

Endometritis spreads by the discharge of infected animals. Cows which have endometritis, usually have a whitish, foul-smelling, dirty discharge from the vulva. This discharge is just pus, with a lot of bacteria in it. The discharge is dangerous for cows in late pregnancy and for newly calved cows.

It takes some weeks before infected cows start to produce 'white discharge'.

Consequences of endometritis are:

- lower reproduction, because many infected cows do not come on heat; some infected cows do come on heat, but do not conceive;
- decline in milk production;
- loss of condition.

The disease can largely be *prevented* by very good hygiene, as described above.

A veterinarian can *treat* endometritis. As always, prevention is better than treatment.

In case of extensive grazing, metritis is seldom a problem. But where dairy herds are permanently housed (zero grazing), metritis can be a serious problem.

Good feeding

When cows do not get enough proteins or minerals, the provision of protein-rich concentrates or mineral licks can improve reproduction. This also applies to (bulling) heifers.

The energy in the ration should also be sufficient and meet the requirements of the animal.

Loss of condition due to an unbalanced ration or a high milk production also lowers reproduction. Such cows have weak heat signs or do not show heat signs at all.

Veterinary measures

With the aid of good records, problem cows in the herd can be traced. Such cows should then be examined by a veterinarian as soon as possible.

Cows to be checked by a veterinarian are:

- cows not seen on heat up till around 60 days after calving (endometritis? abnormal ovaries?);
- cows not conceiving after three or four matings/inseminations;
- cows not observed in heat eight weeks since the last mating/insemination (pregnancy diagnosis).

If most problem cows look normal and if the conception rate is low, wrong insemination timing, a wrong insemination technique or poor semen can be the cause.

When all cows on a farm have a low reproduction rate for no clear reason and when management is in order, specific mineral disorders may be the cause of the poor reproductive performance. A high frequency of retained afterbirth may also indicate mineral deficiencies.

When there are cows with irregular heat intervals, ovarian abnormalities may be the cause.

Culling

The cost of the farm buildings, the fences, etc., and the cost of maintenance feed is the same for high and low production cows. When two cows have the same genetic capacity for milk production, the cow with a poor reproductive performance has a lower production than the normal cow.

For these reasons it is not economic to keep cows with a poor reproductive performance when they can be replaced by normal, healthy animals. Unsatisfactory cows are, for instance, cows not yet pregnant six months after calving. Such cows will have a calving interval of at least one year and three months.

However, the exact definition of 'poor reproduction' within a given herd depends on the herd's average performance.

If it is to be decided whether a cow should be culled for poor reproduction, milk production should also be considered. A low production cow (a cow with a low lactation yield) is culled sooner than a cow with a high lactation yield.

A cow that has been bought at a high price (perhaps an imported animal!) will not be culled soon either. Her calves are valuable.

Sometimes culling is impossible because the replacement rate is too low. In such a case other problems (management!) should be dealt with first of all.

Too often there is not enough culling on a farm; this may lead to overstocking and very low economic returns.

Final remarks

Cows which have conceived do not come on heat again before their next calving; so, not coming on heat three weeks after the last service or insemination may be an indication that the animal has conceived.

However, not coming on heat is no assurance for being pregnant. When one wants to be sure, a pregnancy diagnosis is necessary (from six to eight weeks after the last insemination or service).

It should not be concluded too soon that the bull or the insemination service is the cause of poor reproduction, unless there are clear indications.

When the bull is the problem, because its semen is not fertile, this problem can be solved by using another bull (if available). If the insemination service is the problem, it can be solved by improving the quality of this service or by using a bull on the farm.

4 Major diseases of reproduction

4.1 Endometritis

Endometritis is a uterine infection and is caused by various types of pus-producing micro-organisms. Normally the cervix is closed and prevents bacteria from entering the uterus. However, at calving time the cervix opens for the calf to pass through and bacteria can get into the uterus.

The major causes of uterine infections are:

- poor sanitation at calving time,
- difficult birth, unskilled personnel,
- dirty equipment has been used to assist in the delivery of the calf,
- a retained afterbirth.

Normally a cow discharges mucus with a bloody tinge for 10 to 14 days after calving. Danger signs that indicate an infection are pus in the mucus or a foul odour of the discharge.

Uterine infections delay the necessary healing of the lining of the uterus for the next pregnancy. If the uterus remains infected for three to six weeks after calving, changes take place in the uterus lining that reduce fertility and that may even cause permanent sterility. Often a cow with uterine infection does not produce well. Milk production increases after the infection is cured.

Sometimes the infection in the uterus is very mild and the mucus discharge (with flakes of pus) is only visible when the cow is on heat. Often mildly infected cows are repeat breeders. It is very necessary to detect **early** the appearance of pus in the mucus discharge.

Under otherwise favourable conditions cows will often recover from uterus infection with time. Especially 'heat' has a healing influence. Antibiotics may be infused into the uterus to stimulate the natural healing process. Stubborn cases may require more than one treatment. Strict sanitary procedures should be followed when infusing the uterus. In addition, antibiotics may also be given intramuscularly to treat severe cases of endometritis.

Remember that milk from a cow treated with antibiotics must be withheld from the market for a prescribed period of time.

Many uterine infections can be prevented if good sanitary practices are applied at calving time.

Infected cows should be kept isolated because the disease can spread to healthy cows that come into contact with the infected discharge (pus).

Especially when cattle are permanently housed (zero grazing), endometritis can be a serious problem.

4.2 Abortion in cattle

Generalities

'Early embryonic death' occurs between day-8 and day-20 after fertilization, before the fertilized egg hatches in the uterus. This is a very sensitive period for the embryo.

Early embryonic death happens quite often. If the embryo dies before day-18, the cow will come on heat normally; if the embryo dies after day-18, heat may be delayed somewhat.

'Late embryonic death' is death between day-20 and day-45.

Embryonic death before day-45 usually goes unnoticed; the embryo is broken down by enzymes and is then absorbed by the bloodstream.

Around day-45 all organs are present in principle and the calf has its definite form.

Abnormalities in respect of the chromosomes is probably the most common cause of embryonic death. Insemination carried out too early or too late may also be the cause of embryonic death, just as improper feeding or stress.

Infections and diseases may also cause embryonic death.

Hence, embryonic death is a multi-factor problem. Correct insemination timing, hygiene, prevention of stress and proper feeding (no sudden changes) help.

In cattle the length of the gestation period is about 40 weeks (280 days).

When considering the birth of calves we distinguish:

- normal calving
- partes praematurus (early birth)
after a pregnancy of at least **32** weeks; by this time the body of the calf is fully covered with hair and the calf is viable generally
- partes immaturus (birth of an unfinished organism) or *abortion*
after a pregnancy of **less** than 32 weeks and more than two months; at this stage the foetus is not yet viable.

In other words, 'abortion' is the untimely birth of a non-viable but fully developed foetus.

In principle there are two direct causes of abortion:

- 1 The corpus luteum stops functioning and the foetus is expelled. The corpus luteum is very sensitive to high body temperature (fever). Hence all diseases with fever may lead to abortion. Characteristically the expelled foetus looks 'fresh' just like the afterbirth if normally expelled.
- 2 Pathogenic germs attack the foetus and/or the placenta. The foetus and its placenta become diseased and die. Often the foetus swells (oedema) particularly its belly. Because of these changes the afterbirth is often retained.

Sometimes the foetus is not immediately expelled after its death in the womb. The foetus may dry up in the womb; this happens in particular before the 5th month of pregnancy. The foetus is 'mummified'. Between death and mummification is a period during which the foetus is partly more or less 'fluid' and especially (pieces of) bones may be expelled.

A 'mummy' may stay in the womb for a very long time. Nine months may pass and nothing happens. A good herdsman (farmer) will have noticed beforehand that something is wrong and will call for a veterinarian. A treatment with hormones will usually lead to the 'birth' of the mummy.

In *cattle* abortion is *more common* than in the horse and in smaller ruminants; in the pig its frequency is lowest.

The external signs of an approaching abortion are the same as in normal calving but *less obvious*:

- swelling of udder and teats,
- loosening of the ligaments connecting the tail head with the pelvis,
- greyish bloody discharge from the vulva,
- the cow may be a little restless and strain every now and then.

Note that especially in the first half of the gestation period an approaching abortion may hardly be noticeable.

During an abortion the activities of the female tract are more or less the same as in normal calving, but everything goes in 'slow motion'. This may lead to complications. For example, relaxation of the cervix may take several days; during this time bacteria of all kinds can penetrate the uterus (from the vulva) and cause (secondary) infections.

Any case of abortion may lead to large-scale **dissemination of pathogenic germs!** Therefore it is absolutely necessary

- to recognize the first signs of an approaching abortion and to report it immediately,
- to separate the cow from the herd and to bring it to a calving pen or box before the foetal membranes rupture (a place reserved specially for abnormal situations),
- to prevent the dissemination of germs with the amniotic fluid, the aborted foetus and the afterbirth; the attendant must wear special clothing, rubber boots and gloves and use disinfectants abundantly (this is also for his/her own protection!),
- to send certain parts of the foetus and afterbirth to a laboratory for diagnostic purposes (if possible and desirable); the remaining parts must be incinerated or at least be buried deep and covered by a layer of quick lime,
- to disinfect the pen itself after its use (no germs should be carried away from the pen); disinfect also the cow, boots and clothing, tools, buckets and straw and maintain these precautions for several weeks (in the case of Brucellosis),
- to send blood samples from the cow for a series of serological tests (if desirable and if possible).

For diagnostic purposes, the abomasum (true stomach) of the foetus together with its contents, the caecum of the foetus and the mushroom-like cotyledons of the afterbirth are particularly important.

Especially when the cows live close together, everything should be done to prevent the spread of the pathogenic germs involved in abortion.

What causes abortion

Infections are normally the most important cause of abortion. For this reason abortion is usually **contagious**. When several cows in a herd abort within a relatively short time, one should suspect contagious abortion.

In countries where the bacterium *Brucella abortus* exists, this bacterium is usually the most important cause of abortion. Brucellosis is often called 'contagious abortion'.

However, there are many other causes of (contagious) abortion and for that reason it is often difficult to establish the exact cause of abortion.

The following is an overview likely to cover abortion everywhere:

- The cause may be in the cow herself: more abortions in older animals, breed and family, liver not functioning properly, cow over-sensitive to certain medicines or other products including feed-stuffs.
- Feeding may play a role: malnutrition, lack of minerals etc., sudden feed changes, large amounts of cold water or cold feedstuffs, a.o.
- The care of the cows: transport, fear, accidents; insemination of a pregnant cow; medicines are toxic sometimes and may cause abortion, especially hormone treatments.
- Diseases; any disease may cause abortion. Diseases generally weaken the body and as such may lead to abortion. Fever has a negative effect on the corpus luteum. Especially parasitic infections stimulate abortion.
- Many different kinds of pathogens can cause abortion in cattle. We mention:

viruses:

IBR/IPV (Infectious Bovine Rhinotracheitis; Infectious Pustular Vaginitis),
BVD (Bovine Viral Diarrhoea)

and other viruses

bacteria:

Brucella abortus (→ brucellosis, abortus Bang, Bang's disease)

Campylobacter foetus

Leptospira (→ leptospirosis)

Chlamydia

Salmonella

Listeria (→ listeriosis)

and other bacteria

protozoa: *Trichomonas foetus*

fungi: *Aspergillus* (in feedstuffs)

4.3 Some specific infections

Brucellosis (Bang's disease)

Summary

Brucellosis is a bacterial disease most often spread by:

- an aborted foetus, afterbirth or placental fluids,
- feed or water infected with vaginal mucus from an infected cow,
- direct contact with an infected cow or bull.

The disease is sometimes called *contagious abortion* because it is so easily transmitted from one cow to another.

Man may contract *undulant fever* by drinking unpasteurized milk from infected cows. Most cases of undulant fever result from direct contact with vaginal discharge.

After the infected cow becomes pregnant, the brucellosis bacteria destroy the delicate transfer of nutrients from the mother to the foetus. As a result the foetus may be aborted any time but usually abortion occurs after the fifth month of pregnancy.

After abortion occurs, retained afterbirth, infection of the uterus and sterility are common. However, other causal agents may also be involved in this. Therefore a blood test is required for a precise diagnosis.

There is *no cure* for brucellosis, although some cows develop an immunity and subsequently carry a calf full term.

Such cows usually continue to give a positive blood test for life and may spread the disease for long periods of time.

Slaughter of infected animals is the only effective way to eliminate the disease.

Brucellosis can be *prevented* by routine vaccination of all female calves between three and eight months of age (preferably between three and five months).

Once a country is free from brucellosis, the vaccination programme may be stopped.

Artificial insemination with semen from brucellosis-free bulls is an important weapon in preventing the spread of brucellosis at breeding.

AI stations routinely test their bulls for brucellosis and only use brucellosis-free bulls. They also add anti-bacterial agents to the semen as a precaution.

Dairy cattle exported from Western Europe are free from tuberculosis and brucellosis. But such cattle will be susceptible to infection when imported in countries where these two diseases are normally present in the local livestock population.

Care must be taken to ensure that the susceptible imported animals do not come into contact with any local cattle that might be infected.

Strict hygienic precautions should also be taken to avoid infection being transmitted in any other way.

More details

In countries where the bacterium *Brucella abortus* exists, it is likely to be the most common cause of infectious abortion in cattle.

Other domestic animals such as sheep, pigs and dogs may become infected as well. Occasionally it occurs in the horse.

Men are highly susceptible too.

The germs penetrate through the mucous membrane of the eye (of the milker) and the mouth (of the drinker of raw infected milk) and through lesions in the skin of persons who assist at abortive calving; meat may also be a vector.

Stockmen working with infected livestock are particularly at risk; the same applies to vets.

Symptoms of the disease in men are: general weakness, sweating, painful muscles and joints, headache and *undulant fever*.

As long as the infection has not become chronic, treatment with antibiotics may be successful.

Brucellosis **in cattle** is characterised by inflammatory changes in the uterine mucosa and foetal membranes which lead to *premature expulsion* of the foetus.

The disease exists in many countries outside the 'Western world'.

Where *Brucella abortus* exists, under conditions of extensive range management (for example, nomadic cattle husbandry) brucellosis is not spectacular. But as soon as herds are confined to restricted areas, abortions may occur and weak calves and cases of endometritis and infertility may become significant.

Susceptible exotic cattle introduced to such an environment may suffer from an *acute outbreak of abortion*.

The economic significance of brucellosis:

- loss of calves needed by the farmer for replacing stock or for other purposes,
- reduced milk yield of the cows which are affected,
- losses due to a longer calving interval; repeated matings/inseminations are required before such cows become pregnant again (troublesome and costly!).

Transmission and course

Young calves are relatively insusceptible to infection but they become more susceptible as puberty approaches. *Pregnant females are highly susceptible*. In males the percentage of infected animals is generally lower than in females.

The Brucellosis bacteria are disseminated with the aborted foetuses, the foetal membranes and fluids and the vaginal discharge of infected cows (which may persist for several weeks); the dam's colostrum, milk and faeces may also be infectious.

Consequently pastures, litter, dry roughage and water supplies may become contaminated.

Carrion birds, dogs and other animals may carry the aborted foetuses long distances.

Cattle may ingest contaminated feed or water or lick the genitals of herd mates which have recently aborted or even the aborted foetuses themselves.

Infected bulls may spread the germs with their semen, especially when artificial insemination is applied.

Blood sucking insects, ticks and mites may also transmit the germs.

The Brucellosis bacteria penetrate the body of their next victim through the mucous membrane of the alimentary tract, the respiratory tract or through the eye lids.

Once they have entered the body, the germs lodge and multiply in lymph nodes, the udder, the uterus, joints, etc.

They will quite soon disappear from both the underdeveloped udders of young stock and the 'empty' uteri of non-pregnant cows and heifers.

However, in the well-developed udder of adult animals they will persist for a long time, waiting for the host to become pregnant again; when that happens the germs will move into the uterus. There they cause inflammatory processes which lead to diminishing nutrition of the foetus, to its putrefaction and finally its mortification.

Bovine brucellosis is a **chronic infection** that remains indefinitely in a herd. Young heifers will pick up the infection and may abort the first calf. Usually, each animal will only abort once and more than two abortions are uncommon. A certain degree of immunity develops. So, in the *individual* animal brucellosis is a self-limiting disease.

Diagnosis

Abortion usually occurs some time after the death of the foetus but sometimes the aborted foetus is still alive. In many cases abortion is accompanied by retained placenta ('afterbirth').

Usually there is no severe effect on the general health of the cow which aborts, but its milk yield is often reduced.

In the bull there may be inflammation of the testicles; they become swollen and painful and produce contaminated semen. Appetite and sex drive are reduced.

It is possible to isolate bacteria from foetal stomach contents and from spleen, liver and lung tissues, but it requires a great deal of skill and fresh, clean animal material. Moreover, it is difficult to apply on a large scale.

It is better to recognize an animal carrying the pathogenic germs well before it may infect its herd mates. To this end several tests have been developed; no one test is entirely reliable but a combination of two or more is likely to be effective:

1 Blood serum agglutination tests are practical and quite reliable methods of diagnosing bovine brucellosis

- the serum from an infected animal contains antibodies which will clump the bacteria of the antigen made from a culture of the organism,
- a deposit of bacteria at the bottom of a test tube means a positive reaction (ie. the animal is infected).

Animals which have been vaccinated previously also tend to show a positive reaction to this test. This is inconvenient; therefore another serological test has been developed, namely the

2 Complement fixation test; it is more elaborate but it distinguishes between reactions due to natural infection and those resulting from vaccination.

3 The Abortus Bang Ring Test (ABR) is an agglutination test on **milk**; it is a very sensitive test and is used by dairy plants as a screening test

- the antigen is a coloured suspension of *Brucella abortus*; it produces a definite ring at the cream line when incubated with a small quantity of milk from an infected animal,
- in negative reactions the milk remains bluish and is capped by an uncoloured layer of fat

and other tests.

Control

There is no practical and effective treatment for brucellosis.

Therefore all efforts should be directed towards *control and prevention*. The eventual *eradication* of the disease requires the elimination of all (newly) infected animals.

The following measures should be taken in an anti-brucellosis campaign:

- 1 Apply the ABR test ('milk ring test') to every dairy herd in the region, at three to four months' intervals; in this way the brucellosis status of individual dairy herds can be determined. Milk samples are collected and tested at the milk plant, taking each separate herd *as a whole*.
- 2 **All** animals in a 'positive' herd are then submitted to **individual** blood serum tests; those showing a positive reaction are slaughtered.
- 3 'Clean' herds must be *protected from reinfection*. The greatest danger comes from purchased replacements.

Where possible, new additions should be vaccinated calves or non-pregnant heifers.

If pregnant or fresh cows must be bought, they should originate from brucellosis-free herds (this means at least three negative quarterly ABR tests in succession) and be negative to the blood serum agglutination test individually.

It is advisable to keep such replacements separated from the herd for at least 30 days and to retest them before permitting them to mix with the main herd.

Note: it is clear that such a campaign can only be held in regions with a certain infrastructure of milk collection and animal health.

Vaccination

The first vaccine which was successful against bovine brucellosis was that prepared from the 'strain 19' organism. Strain 19 vaccination can be applied at all ages but in the adult animal it gives a positive reaction to diagnostic tests for some years afterwards.

In calves, however, a good degree of brucellosis resistance is obtained, while the animals cease to show a positive reaction by the time of first calving.

In the Netherlands (Western Europe in general), vaccination against bovine brucellosis was stopped many years ago. The country is free of the disease and, moreover, a number of countries to which breeding stock is sold do not accept cattle from countries where such vaccinations are used.

Another strain of brucellosis bacteria, number 45/20, is sometimes used as a supplementary vaccine. This dead vaccine induces resistance for a short time at any age of the animal, while positive reactions to diagnostic tests fade away soon after its application.

Disadvantages are that two doses (at specified intervals), and on top of that annual booster injections, are required to develop a satisfactory immune response; this is laborious and costly. Occasionally local and febrile reactions to the injection occur.

As a temporary aid to control of brucellosis, both vaccines have their applications, particularly in situations where initial infection is widespread and speedy action is required.

It must be borne in mind that in areas where the disease is widespread eradication is **not** possible on a purely voluntary basis.

The brucellosis germs spread too easily, for instance by direct contact across poorly fenced boundaries, on premises where animals have aborted, through vehicles, and so on. Sanitary regulations are indispensable (and must be enforced).

Leptospirosis (Lepto)

Cows most often contract lepto from the urine of infected cows or other infected animals. Natural mating can also be a route of infection.

Milkers may also contract the disease.

High fever and poor appetite are usually the first symptoms. Pregnant cows may abort as a result of the disease, regardless of the stage of gestation.

Abortions are most frequent in the last three months of pregnancy, however.

The kidneys and blood cells may also be affected by the organisms. As a result, bloody urine and anaemia are primary symptoms. Symptoms resembling mastitis are also common. The milk contains yellow, ropy masses.

For positive diagnosis blood and/or urine are usually tested to isolate the infecting organism.

Not everything is known about prevention and control of leptospirosis. The animals can be tested yearly to help prevent spreading of a lepto infection in a herd.

Artificial insemination with semen from non-infected bulls is also helpful. Vaccination is recommended if the herd is in an area where lepto is common.

Good protection against lepto is possible if the correct lepto vaccine is used. Vaccines must be administered every 6 to 12 months for good protection.

Campylobacter foetus

Summary

Campylobacter foetus is a bacterium transmitted by natural mating. The infected bull may not show any external symptoms. Less frequently, cows may contract this disease by direct contact with infected cows.

Repeat breeding problems or abortions between the fourth and seventh month of pregnancy are the first indications of this infection. Most infected cows in the herd may require several services before they settle. Heat periods are irregular and many cows will have uterine discharge. The reproductive performance is very poor.

For positive diagnosis a trained technician should culture the vaginal mucus from the cow or fluids from a freshly aborted foetus to identify the micro organisms.

Of the bull, mucus collected from the prepuce should be cultured.

Cows develop an immunity a few months after infection with this bacterium.

New animals added to the breeding herd will often become infected by the bull.

Following an infection, which may or may not cause abortion, some cows remain less fertile or sometimes totally sterile.

There is a vaccine available to protect cows against Campylobacter foetus. Two vaccinations given three weeks apart are required the first year, followed by one yearly vaccination afterwards.

Campylobacter foetus can also be prevented by using artificial insemination. In countries where the disease is prevalent, most AI stations test their bulls for this disease and use only negative (non-infected) bulls.

In this way the spread of the disease from the bull to the cow can be completely prevented.

As a precaution, on many AI stations anti-bacterial agents are added to the semen as well.

More details

In cattle, *Campylobacter foetus* (campylobacteriosis or vibriosis as it was and is still called) is a venereal disease. In sheep, however, it is assumed that the transmission of the bacteria occurs when the sheep ingest contaminated feed and water.

Campylobacteriosis should be suspected to be present when the majority of the cows and heifers in a herd are returning to service, either regularly or irregularly, especially if this coincides with the introduction of a new bull.

The bull may harbour the organism for long periods on the surface of the penis and the inner wall of the prepuce without showing any lesions.

In the female, the infection is temporary and immunity is established in about three months.

Course of the disease and its diagnosis

The primary effect of campylobacteriosis is *temporary infertility*; abortion is of secondary importance.

An irregular oestrus cycle is a prominent sign. In fact the cow has conceived but the embedding of the fertilized egg in the uterus is interrupted. This interruption must be seen as a defensive reaction of the mucous membrane of the uterus to the presence of the bacteria.

Early embryonic death is the result; normally the embryo is absorbed and a new cycle starts.

If the embryo is expelled, it is often so small that it goes unnoticed.

Some of the cows served by an infected bull may carry their calves to full term.

If not, reinfection takes place with continued service by the (same) infected bull. But gradually immunity is built up and early embryonic death does not occur any more.

However, in such cases the foetal membranes and the cotyledons may still be damaged in such a way that the foetus is aborted (4th to 7th month of pregnancy); this abortion is usually accompanied by retained afterbirth.

Foetal stomach fluid is the best source of pure cultures of the bacterium, but its application is limited:

- only about 10% of infected cows abort sizable foetuses and
- abortion is a relatively late manifestation of bovine campylobacterial infertility.

It is also possible to isolate the bacterium from oestrus samples of vaginal or cervical mucus; positive results may be expected about four weeks after exposure to infection.

It is difficult to isolate the bacteria from the semen or from material sampled from the prepuce of the bull.

However, if a female served by the herd bull is found to be infected, it is most likely that the bull is infected as well.

Blood serum agglutination tests are not reliable with this particular disease.

The antibodies accumulate locally in the female genital tract and therefore vaginal mucus is used. Agglutinating antibodies have been found 60 days after experimental venereal infection and they persist for about seven months.

The test should be applied on a herd basis. **All** non-pregnant cows that were first exposed to service more than two months previously should be included (a single animal might show a false reaction, either positive or negative).

Freedom from campylobacteriosis is essential for AI bulls. This can be ascertained by test-mating a new bull to two virgin heifers. The heifers act as natural incubators. If the bull is infected, the bacteria may be recovered from vaginal mucus samples about four weeks after service and/or a positive agglutination test of the vaginal mucus will be obtained about sixty days after service.

Control

An infected bull transmits the bacteria not only by natural mating but also with its semen if this is used for artificial insemination. Treating the semen with antibiotics reduces the risk of the latter.

It may be possible to treat infected bulls but so far no practical method has been developed.

Infected cows become immune within a period of three to six months after they have been exposed to service by an infected bull (it is recommended to give them sexual rest until they have completed this period).

Artificial insemination is the best method of controlling this disease, provided that:

- the AI bulls have never been used for natural mating,
- they are not infected by contact of the penis with contaminated instruments or with the rump of the dummy cow when the semen is collected,
- the inseminations are performed under strict hygienic conditions (the equipment that is used; the hands of the inseminator).

If natural mating has to be continued, the unexposed females should be kept isolated from the exposed cows; only non-infected bulls should be used on this clean herd.

The separation must be strictly maintained.

By means of *vaccination* satisfactory protection of susceptible stock has been achieved, especially in beef herds under range conditions. Usually the females are vaccinated at least two weeks before breeding and the procedure is repeated annually.

Vaccination of the bull was never very successful until the 'Belgian vaccine' was introduced. The systematic application of this vaccine has been reported to reduce the percentage of affected bulls spectacularly.

Trichomonas foetus

Summary

Trichomoniasis is also a breeding disease. *Trichomonas* is a protozoan (singular cell, microscopic) transmitted by natural mating. Even though bulls never show external symptoms of the disease, they are usually the source of infection in a herd.

As a result of infection, abortions occur during the first four months of pregnancy.

Large quantities of greyish, abnormal fluid may be discharged during the first half of pregnancy as a result of uterine infection caused by trichomoniasis.

In open cows, heat periods are irregular and often many services are required to settle the cow.

For a positive diagnosis the organisms which cause the disease must be identified microscopically in the fluids from the aborted foetus, the vagina of the cow, the prepuce of the bull or in the semen.

There is no reliable treatment. Cows which have aborted usually develop an immunity.

The anti-bacterial agents commonly used in semen by AI centres may not be as effective in controlling this disease as they are for *Campylobacter foetus*.

The best method of preventing trichomoniasis is using semen from non-infected bulls.

In countries where the disease is prevalent, AI centres test their bulls regularly to guard against this disease.

More details

Bovine trichomoniasis is a venereal disease spread all over the world.

Like campylobacteriosis, it is an insidious disease; that is to say that it may have been present in a herd for months before it is recognized.

When it first affects the herd the infection rate is high. Nevertheless, as females develop resistance, fertility may (again) reach such a level that the owner never becomes aware of the presence of the disease.

The organism which causes the disease is a flagellate protozoan, which is found only in the genital tract of male or female cattle. At the AI centre the organism may spread from one bull to another by indirect contact (via the rump of the teaser or the dummy or via contaminated equipment and hands). Between bull and cow, transmission generally only occurs during mating.

A number of cows and heifers served by infected bulls conceive and either carry to term (without any signs of infection) or abort within two to four months. Others return to multiple services and may not show clinical symptoms.

Note:

- early abortion (first third of pregnancy period) is usually associated with trichomoniasis,
- abortion during the middle third of the pregnancy period is usually due to campylobacteriosis,
- late abortion (last third of the pregnancy period) suggest brucellosis.

The death of the foetus is often accompanied by its maceration and the accumulation of pus or fluid in the uterus. In such cases manipulation of the uterus often provokes a discharge from the vulva in which motile trichomonads can generally be demonstrated.

In Europe the widespread use of artificial insemination since about 1950 has made it possible to control the disease. In this respect, the main advantage of artificial insemination is that it prevents infection of the bull.

Although transmission by artificial insemination is reduced by the usual dilution methods of semen, it can still occur.

Diagnosis

In the female, infection is characterised by:

- a low conception rate (repeat breeding);
one must become suspicious when several females fail to conceive to a bull of which the semen is found to be of good quality (number and motility of male cells),
- a profuse mucoflocculent discharge from the vulva,
- early abortion (2nd to 4th month of pregnancy); often a foetus of no more than 6 to 7 cm body length,
- pyometra, which means accumulation of pus in the uterus; the corpus luteum persists and hence oestrus does not occur.

The tentative diagnosis is confirmed when one finds the organism in at least one animal of the herd. Microscopic examination of mucus obtained from the vagina shows the motile trichomonads.

In the bull, the trichomonads are present in the prepuce, especially in the fornix and on the glans penis.

Treatment and control

In the female, the disease is self-limiting and infection induces a relative degree of temporary resistance.

On the other hand the bull remains permanently infected unless properly treated.

As soon as the presence of the disease in a herd is established, the unexposed females should be separated and artificially inseminated.

Exposed females showing pyometra or other severe genital abnormalities can better be eliminated from the herd.

Less severe cases must be treated properly and none of the healthy-looking animals of the exposed group should be used for breeding before their third **regular** heat period.

IBR/IPV (Infectious Bovine Rhino-tracheitis & Pustular Vaginitis)

IBR/IPV is a disease caused by a virus. In Holland it is commonly called 'cow flu'.

Several forms of the disease are recognized, for instance pink eye, pneumonia and vaginitis.

The disease may cause severe economic losses: less production and the cows may even die; embryonic deaths, abortions and stillbirths occur.

It is a very contagious disease.

Vaccination is possible, as a preventive measure.

Appendix

Article: Optimizing and modernizing extensive cattle farming

Editor: the text of the following article is from Katrien van 't Hooft and Vivienne Lewis, both veterinarians, and written after several years' experience with dairy farming in a Central American country.

Conditions may be different elsewhere but it is interesting to note that genetic improvement of the cattle (not to mention artificial insemination) only appears late in the article!

Many people see the use of purebred dairy cows, artificial insemination and, most of all, producing irrigated fodder crops for feeding in the dry season as intrinsic to modern dairy farming. In the following text we adhere to these principles, but also recognize that in many situations extensive cattle farming may be the most common practice.

How can extensive cattle farming be characterized?

In extensive cattle farming the cattle graze all the year round on low quality pastures, are hand-milked with the calves allowed to suckle before and after milking. The bulls usually run permanently with the female cattle. Production is low due to severe feeding constraints in the dry season, combined with the adverse effects of infectious and parasitic diseases.

The cattle are mainly dual-purpose, producing milk and beef, as well as herd replacements and draft animals. Usually tropical cattle breeds are utilised, as they survive long periods of food shortages better than non-tropical breeds, and have a greater resistance to common diseases. Often tropical breeds are crossbred with european dairy cattle breeds, giving good results as long as the resultant cattle do not have too much pure dairy blood.

Extensive cattle rearing is often seen as synonymous with 'backwardness' and underdevelopment, because of the perceived low productivity of the cattle. However, for many farmers in tropical regions it is often more important to produce milk and meat at minimal costs rather than concentrating on the total amount produced. Thus, extensive cattle rearing is often the most economic way to keep cattle.

More intensive dairy farming

In areas near towns and cities the situation is different for dairy farmers. Milk prices may be higher whilst transport costs are reduced. This should give the producer the incentive to improve milk yields per cow, changing from an extensive to a more intensive dairy farming enterprise.

Technical strategy to optimise or intensify extensive cattle rearing

The following strategy can be applied to all levels of cattle management, adapting it to the specific reality of each farm. It is based on improving essential cattle management factors that are possible and economically feasible for the farmers involved. It is derived from the present-day cattle management systems used by farmers in Nicaragua, Central America, and should be adapted to local circumstances when used in other countries.

The strategy recommends step-wise modifications and is divided into **three phases**:

Phase 1 - Basic phase for all cattle farmers

Phase 2 - Extra attention given to cattle feeding

Phase 3 - Phase of long-term, larger investments

Farmers who rear their cattle in extensive systems will be able to optimise their enterprises by applying phase 1. They may also be able to apply parts of phase 2 depending on their circumstances. Farmers who intend to intensify extensive cattle enterprises, will need to apply all 3 phases.

Improving cattle management and productivity is a long-term process, which requires not only extensive technical knowledge and experience but also organizational and problem-solving skills.

Phase 1: Basic phase for all cattle farmers

The purpose of this first phase is by using very low-cost interventions, cattle mortality can be reduced and production can be slightly increased, encouraging greater farmer-interest. This is achieved **by guaranteeing 8 minimum requirements**, as well as some basic management and organizational factors. Cattle improvement will be noticed within a few months, especially decreased mortality and better physical condition, motivating the farmer to carry on with his/her endeavour.

The small investment necessary to provide this basic phase can be obtained by selling one or two poor quality animals.

1 The **8 minimum requirements** for extensive cattle rearing.

The relative importance of each requirement depends on the individual characteristics of each farm, the type of cattle and production goals of the farmer

- Sufficient clean drinking water (twice a day at least).
- Strategic supplementary feeding during the last 3 months of the dry season for cows-in-milk, small and recently weaned calves and sick or weak animals. This feeding aimed at survival, can be based on traditional feeds like cattle sorghum, or on crop residues, hay and other cheap and easy to obtain products such as fruits and seeds of mainly leguminous trees.
- Give sufficient common salt.
- Adequate grassland management; rotational use of fields and the prevention of overgrazing and weed infestation.
- Vaccinate twice a year against Anthrax and Blackleg.
- Deworming of young cattle, plus preventive measures to reduce high worm burdens.
- Regular dipping / spraying (ticks and hypoderma).
- Good general care of all stock, especially cows at calving time, new-born calves and weak or sick animals.

2 **Essential organisational factors** (eg. for cooperative farms).

- Appoint the most suitable person to be in charge of the cattle.
- Guarantee the stability of the people working with the cattle.
- Improve planning of basic management activities, on the basis of evaluation of past performance.

3 **Essential cattle management factors.**

- Castrate all male cattle over 1 year old that run with the female cattle, with the exception of the bulls used for reproduction.
- Sell/exchange bulls used for reproduction that have been working on the farm for 4 years or more.
- Separate young heifers from the bulls (if possible).
- Sell animals in case of overgrazing.
- Revise and possibly reduce the time the milking cows stay in the corral with their calves after milking.
- Improve hygiene and milking techniques.
- Start a small veterinary kit, including the most essential medicines in case of an emergency.
- Enumerate all female animals, preferably indicating year of birth.
- Start keeping records: costs and income from cattle enterprises, recording of births, deaths, sales and bought-in animals, and total numbers by category.

Phase 2: Extra attention given to cattle feeding

Maintain the standards that have been set during phase 1. This may not be so easy as it seems and requires continual analysis and evaluation!

Some of the increased farm income due to decreased mortality and increased production can now be invested in improving supplementary feed for the dry season. This could include:

- The construction of simple feed troughs.
- Supplying mineral salts or bone meal in combination with common salt.
- Supplementary feeding during 5 months of the dry season instead of 3 months.
- Sowing legumes.
- Growing forage crops e.g. sugar cane or elephant grass.
- Buying and installing a simple chopping machine.
- Adding molasses and urea to the forage.
- Mixing home-made concentrates.
- Making silage.

(editor: see AGROMISA publication 'Modern Dairy Farming in Warm Climate Zones, Book I, for details)

Which of these interventions to introduce and how to introduce them, depends on local conditions and circumstances, the preferences of the farmer and the prices of meat, milk and other dairy products as well as input prices.

Other important points at this stage are:

Genetic improvement of the cattle; e.g. the acquisition of a superior quality bull, or better selection of female cattle, which is now possible due to lower mortality rates.

Further grassland improvements; these may take several years.

Provide several fields for young calves. Improve methods of grazing. See earlier chapters for details.

Control of vampire bats.

Brucellosis control.

Extend record keeping.

Phase 3: Phase of long-term, larger investments

Depending on the cattle enterprise, the goals and interest of the farmer and the current government agricultural policy (input/output prices, subsidies, markets etc.), it may be rational to make *some larger investments that give long-term results*. However, it must be stressed that making large-scale investments without routinely maintaining the improvements realized in phases 1 and 2, will **not** increase cattle production or profitability.

Long-term investments that could be considered are:

- 1 More field divisions, to facilitate improved grassland and cattle management.
- 2 Construct water tanks and reservoirs in farms where water supply is a problem in the dry season.
- 3 Buy-in more cattle in cases of low stocking rates and general under-productivity. Ensuring appropriate stocking rates will assist a grassland improvement programme.
- 4 Further selection and genetic improvement, by establishing a rational breeding programme. However, it is not recommended to breed cattle with more than 75% of pure dairy blood.
- 5 Supplementary feeding of the in-calf cows and heifers during the dry season. These animals do not usually receive any extra feeding but as part of a more intensive cattle management programme it should be possible to offer supplementary feeding to all cattle on the farm.

However, many farmers practising small-scale extensive cattle farming, will **not** find it profitable to make these large-scale investments.

End of article.