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Reproductive cycle, fertilisation and embryo development

How a cow cycles

True standing *heat (oestrus)* occurs when a cow stands to be served by a bull or to be mounted by another cow. It can last between 4 to 27 hours, with the average length being 18 hours. The average period between heats (i.e. length of the *oestrous cycle*) is 20 to 21 days.

Ovulation involves the release of an egg (*oocyte*; see *Figure 2.1*) from a mature *follicle* during the oestrous cycle. In the case of non-identical twins two eggs are released at once. Ovulation usually occurs 24 to 30 hours after the onset of heat, or 10 to 12 hours after the end of heat (see *Figure 2.2*).

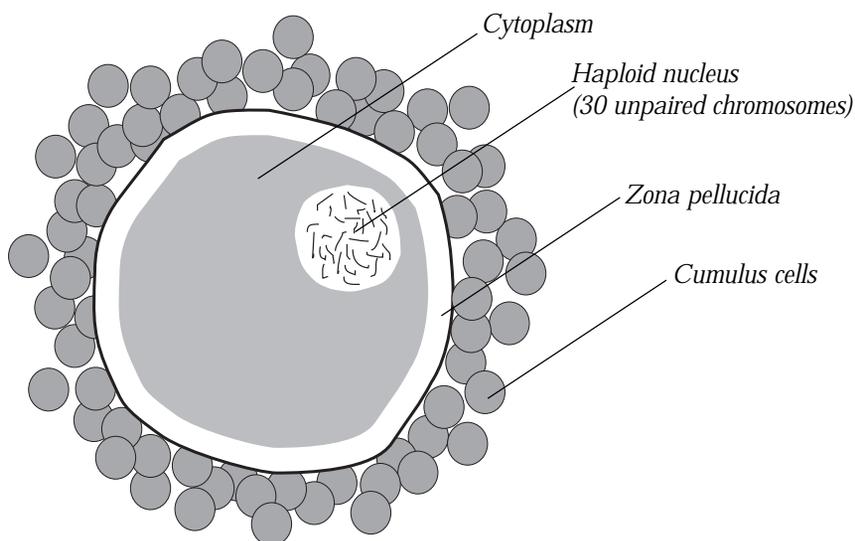


Figure 2.1: An oocyte from a cow

After the end of heat a structure called the *corpus luteum* ('yellow body') develops in the space in the ovary previously occupied by the ovulatory follicle.

The mature corpus luteum controls the cycle for 15 to 18 days. If *fertilisation* occurs and the cow becomes pregnant, the corpus luteum continues to work and secretes the hormone *progesterone*, which is required for the establishment and maintenance of pregnancy.

If fertilisation does not occur, the corpus luteum begins to regress (i.e. shrinks) about 16 days after the last heat, allowing another large follicle to mature and ovulate. Another heat period then begins, usually 20 to 21 days after the previous heat.

After regression the corpus luteum becomes a white or pale brown body, known as a *corpus albicans*, which ultimately becomes scar tissue.

Reproductive cycle of the cow

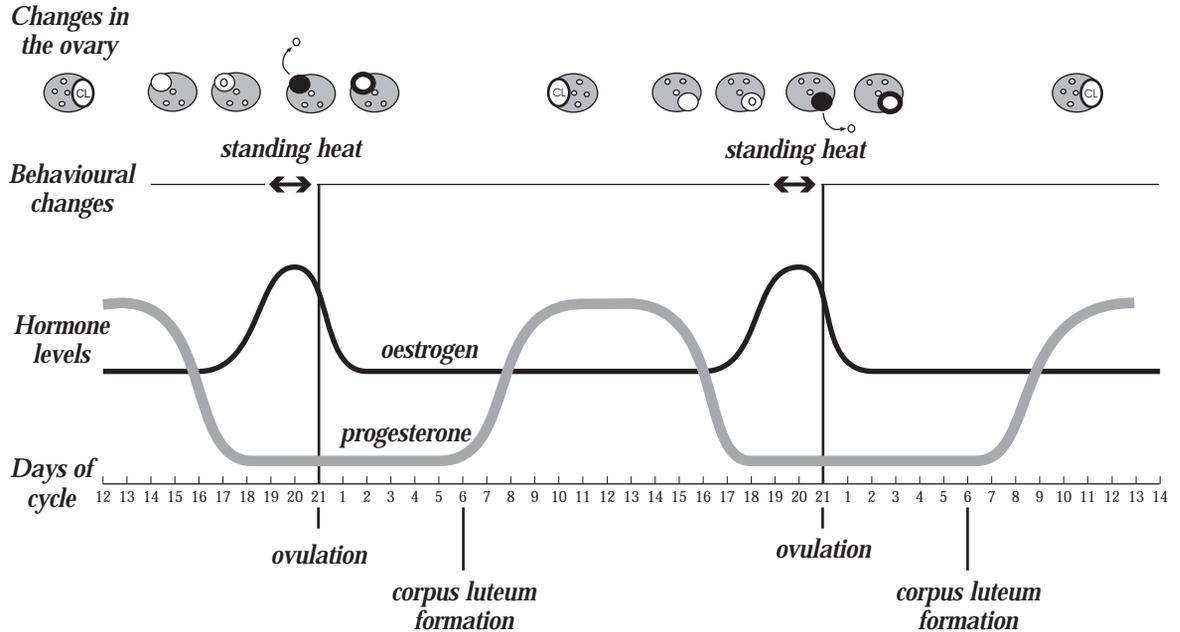


Figure 2.2: Reproductive cycle of the cow

Follicle development

The egg grows inside a fluid-filled sac called a *follicle* under the influence of *Follicle Stimulating Hormone (FSH)* from the brain. Surrounding the egg is a shell, called the *zona pellucida*.

When a heifer is born each of her ovaries contains 50,000 to 100,000 eggs or oocytes. By the time she is two years old most of these have died and only about 5,000 eggs remain in each ovary. Of these 10,000 remaining eggs, only 5 to 10 of them will result in calves on the ground. The remainder gradually die off.

One very important difference between males and females is that when a female is born she has her lifetime complement of *germ cells* (ova or eggs), whereas a male produces germ cells (sperm) continually throughout his life.

Thousands of follicles exist in each ovary with only one ovulating per oestrous cycle. During a normal cycle in a cow many follicles begin growing in the ovary. Growing inside each follicle is an egg. *Figure 2.3* shows follicle development throughout the oestrous cycle.

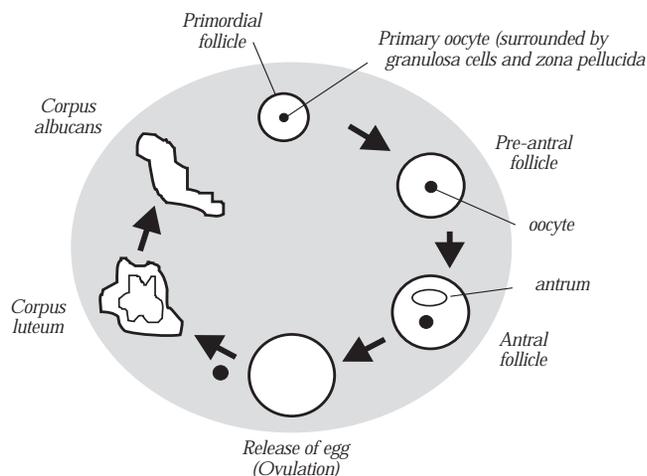


Figure 2.3: Follicle development in the ovary of the cow

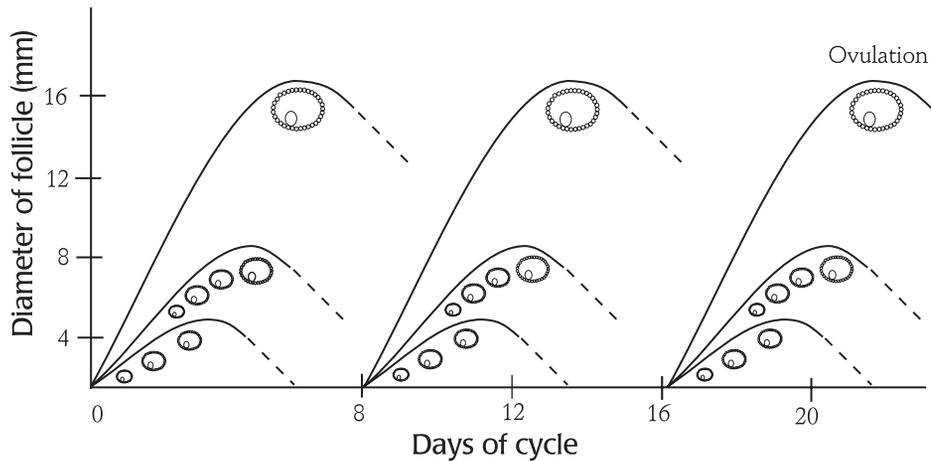


Figure 2.4: Follicular wave development in cattle

Follicles grow in 'waves' and there are usually three such waves during the 21-day cycle (see Figure 2.4). In some breeds of cattle, especially *Bos indicus* breeds, there may only be two waves but the principles are the same. Around 20 to 50 follicles begin growing in each wave and one follicle grows to a larger size and 'dominates' the other follicles, which then die off. In the third wave the large follicle (*Graafian follicle*) goes on to release the egg (*ovulate*), about 10 to 12 hours after the end of heat. The Graafian follicle secretes the hormone *oestrogen*, which is responsible for the signs of heat.

Ovulation

Ovulation is triggered by an increase in concentration of *Luteinising Hormone* (LH) from the brain. The egg is then caught in the oviduct, where it can remain alive for several hours. It must be fertilised within 10 hours or so after release from the ovary, otherwise it dies. It is important that there are sperm present in the oviduct to fertilise the egg after it has been released.

Semen

The *semen* of cattle is a white or creamy coloured fluid consisting of *spermatozoa* (*sperm*) and *seminal fluid*. Sperm are produced in the testes and the seminal fluid is added during the process of *ejaculation* from glands such as the prostate gland.

Individual sperm consist of a head (containing the *nucleus*) and a *tail*. The tail is for motility (see Figure 2.5 below).

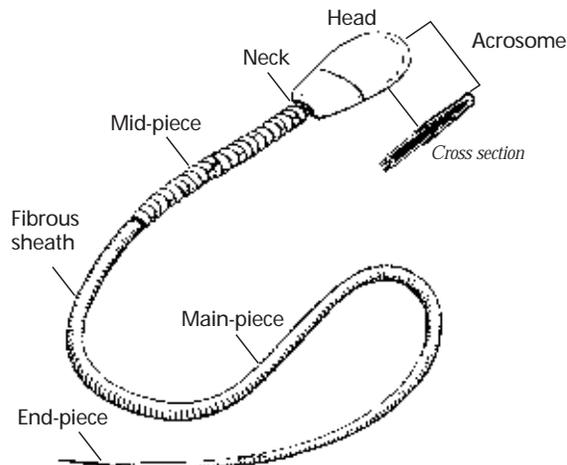


Figure 2.5: The components of sperm

Fertilisation

When the sperm are deposited either at the cervix by the bull or into the uterus by artificial insemination (AI) they are rapidly transported up to the oviducts (fallopian tubes), arriving there in three to four minutes. Transport of the sperm is caused by wave-like contractions of the uterus, mediated by the hormones *prostaglandin* and *oxytocin*. Rough handling of the cow and stress can cause the release of *adrenalin*, which stops these contractions occurring and may result in a lower conception rate.

Sperm will survive in the vagina of a cow for about six hours. They will survive in the cervix for up to 36 hours and in the uterus for at least 24 hours.

During fertilisation the sperm penetrates the shell (zona pellucida) and then the *cytoplasm* ('yolk') of the egg. When one sperm has completed this process the egg releases chemicals which prevents other sperm from doing the same. The head of the fertilising sperm separates from the tail and its nucleus fuses with the nucleus of the egg. Immediately before fusing, the nuclei of the sperm and egg are called *pronuclei*. This completes fertilisation, which occurs 24 to 30 hours after the onset of heat, or 10 to 12 hours after the end of heat. The fusion of the nuclei of the sperm and egg is called *syngamy* and this is regarded by many as the true start of life.

Embryo development

The fertilised egg is called a *zygote*. After it divides into two cells it is called an *embryo*. After fertilisation, the embryo moves down the oviduct and into the uterus. Generally the embryo reaches the uterus 5 to 6 days after heat (4 to 5 days after fertilisation). At this stage the embryo has 16 cells and is still surrounded by the zona pellucida. The embryo then goes through the morula stage (where it has between 16 and 100 cells) to reach the blastocyst stage (where it has greater than 100 cells) approximately seven days from heat or six days from fertilisation (see *Figure 2.6*). A blastocyst is characterised by the presence of a fluid filled sac called a *blastocoele*.

Eight to nine days after heat the embryo 'hatches' out of the zona pellucida and continues to grow, floating free in the uterus.

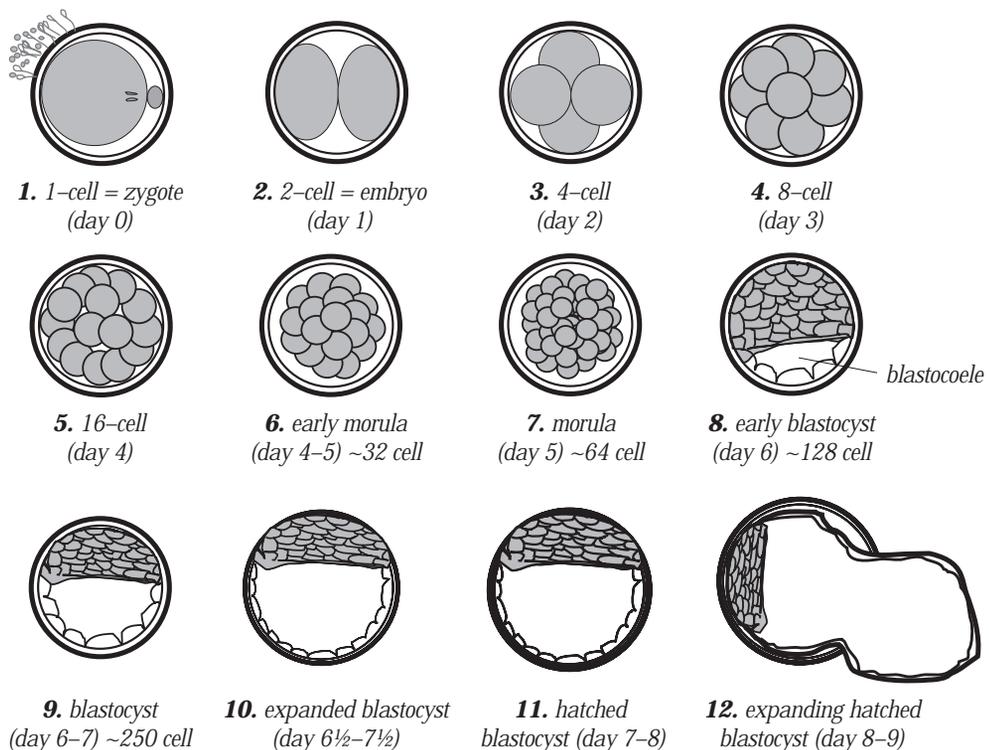


Figure 2.6: Cleavage rates of bovine embryos from fertilisation (approximate only)

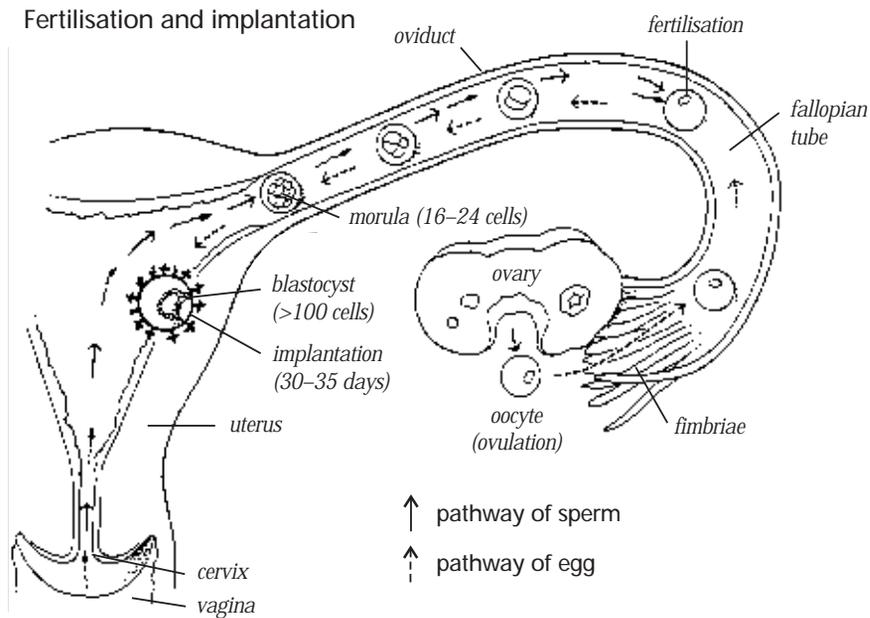


Figure 2.7: Fertilisation and implantation

Thirty to thirty-five days after fertilisation the embryo attaches to the uterine wall (this is called *implantation*). Figure 2.7 gives an overall view of fertilisation and implantation within the reproductive tract of the cow.

At this stage, the embryo is called a *foetus* which develops into a full term calf after approximately nine months. The period from conception to delivery of the calf is called *gestation*.

Pregnancy diagnosis

Pregnancy diagnosis is required a few months after mating or insemination so that non-pregnant cows can be treated or culled. It is also necessary for the certification of cows for sale or insurance purposes, to reduce waste in breeding programs using expensive hormonal techniques and to help in the economic management of cattle production.

Rectal palpation

Rectal examination is the most commonly used method for pregnancy diagnosis in the cow. It can be performed from around day 50 of pregnancy (gestation). The uterus is palpated (touched) through the rectal wall to detect uterine enlargement and other changes associated with pregnancy.

Ultrasound examination

This can be used to detect the developing foetus from as early as 25 days into gestation. It does not harm the animal or the foetus.

Laboratory methods

Progesterone assays are sometimes used to detect pregnancy.

Further reading

Gordon I. (1994), *Laboratory production of cattle embryos*, CAB International, UK.
 Hafez E.S.E. (1987), *Reproduction in farm animals*, 5th edition, Lea and Febiger, USA.