



The (Sexual) Physiology of Sheep

Sheep's reproductive physiology differs from other farm animals', moreover, also differs from other ruminants'.

Vital processes can be experienced at the fetal age of sheep, therefore the sexual activity as well. Lambs become capable of having a normal pregnancy at the age of 6-9 months, thus, they can start the main characteristics of their life performance: the reproduction.

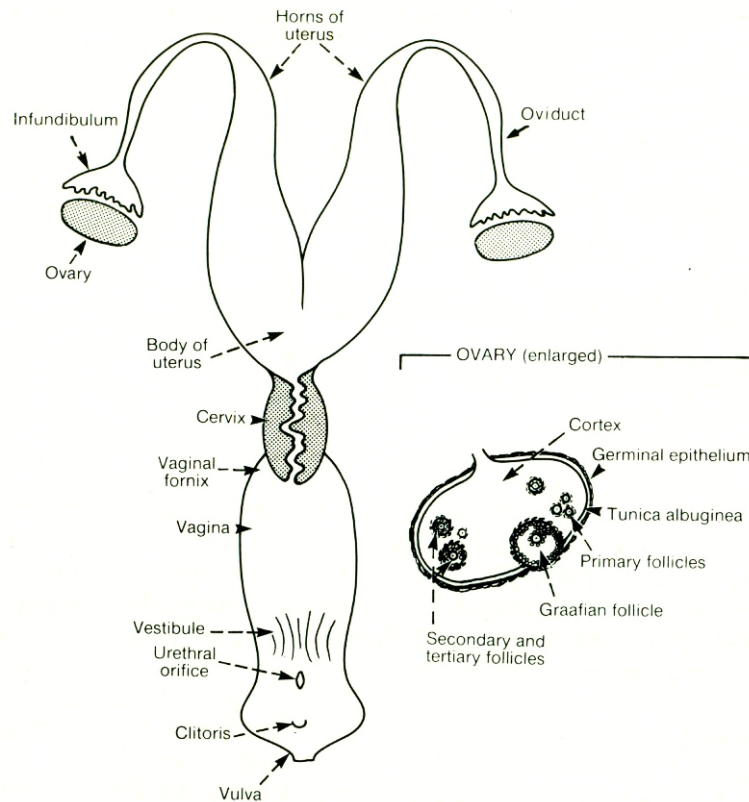
Sheep have particular environmental needs: the nutrition, the environmental temperature, the ram etc. that may affect the sexual activity. According to the cyclical function of the ovary, sheep are seasonally polyoestrus animals. Their cycle lasts for 16-17 days. The oestrus exhibition depends on the luteal activity of the previous cycle. Rams are the best in detecting animals' heat. The period of pregnancy in sheep is between 143-157 days, the average is 150 days.

The lambing and the involution of the genital tract are crucial periods in ewes' reproductive possibility in the future that is why it desires a special attention.

The selection of breeding ewes and the further growth of sheep population have a major impact on economical animal food products production (lamb, milk) and life performance. A breeding ewe should not be replaced unless a better one is available. Mostly 5-7 years old ewes provide multiple births.

The selection of rams for service must be done under strict conditions, because this decision will determine the quality of hundreds of offsprings provided by the ram per year.

Keywords: gonadotrop hormone, trop hormone, sexual maturity, breeding season, oestrus, flushing, pheromone effect, ovarian cycle, progesterone, 17-beta estradiol, oestrus signs, ovulation, follicle, corpus luteum, embryonic/foetal death, pregnancy, lambing, involution, selecting breeding animals.



*The reproductive organs of the female
(from Ref. 1: Figure 5.1)*

The organic function and the hormone production can already be detected in the foetus. Most animals reach the sexual maturity between 6 and 8 months of age. When animals achieve 60-70% of their mature size, they become fully matured for breeding and can be bred.

Originally, sheep species have 2-3 heats per year in autumn, so lambing falls on the spring months when the possibility for abundant fodder consumption is provided.

The period of the breeding season of domesticated sheep is varied enough. On the one hand, it depends on the characteristics of the given species; on the other hand it depends on the climatic conditions of the breeding area, therefore the period of the breeding season may extend from 2-3 oestruses to about 20 oestruses per year. In case of optimal environmental conditions, some species show signs of oestrus almost all the year round – these are the polyoestrus sheep species.

Sexual functions become gradually stronger then weaker during the breeding season. The ovulation number also changes during the season; it is the highest in mid season. Accordingly, ovulation without oestrus may occur during the seasonal transition (in the beginning and at the end of the breeding season). The physiological anoestrus refers to a state with no signs of oestrus. In spite of this fact, the ovarian function will not stop working and during the period of anoestrus, follicles develop cyclically. These follicles will not ovulate at this time.

It can be stated, that sheep reproduction is seasonally polyoestrus.

According to the proliferation of sheep, they occupy an intermediate position between the single birth and multiple births species

Nourished sheep tend to have a strong sex hormone activity.

Adequate nutritional content and quantity provide a moderate improvement in body condition that contributes to the possibility of multiple births during the breeding season. The rate of multiple births is between 6-8% without flushing. This rate can be raised up to 20% with a fortnight flushing, and up to 40% with a 4-6 weeks flushing. Well-nourished sheep's condition not only brings forward the breeding season but also extends it. Nutritional condition of ewes affects the foetal growth. Ewes with poor nutritional condition increase the rate of embryonic deaths.

Rams produce a chemical substance called a pheromone, the smell of which stimulates ewes' sexual function and helps to increase the amount of their LH trop hormone. The pheromone has a slight positive effect on the birth rate of lambs. The ram keeps pushing the heating ewe with his head that makes uterine retraction stronger and makes sperms meet the egg easier.

Sheep's thermal resistance is poor; actually, they are unprotected against hot temperature. If the temperature is too hot, it makes the breeding season delay and cyclic functions worse. Warm weather also makes the conception and the result of the pregnancy worse. Since the weather turns colder in the evenings, in some degree it can neutralize the harm of hot temperature of the days.

The lower environmental temperature accompanies by the higher relative humidity that stimulate sexual functions.

Sheep are short-day breeders (in Europe); their breeding season falls on the time, when length of day begins decreasing.

In spite of the early domestication, sheep kept their original instincts, so previously experienced things in connection with their reproduction, behavior etc. may change, that is why there are hardly or no rules at all.

Sexual function

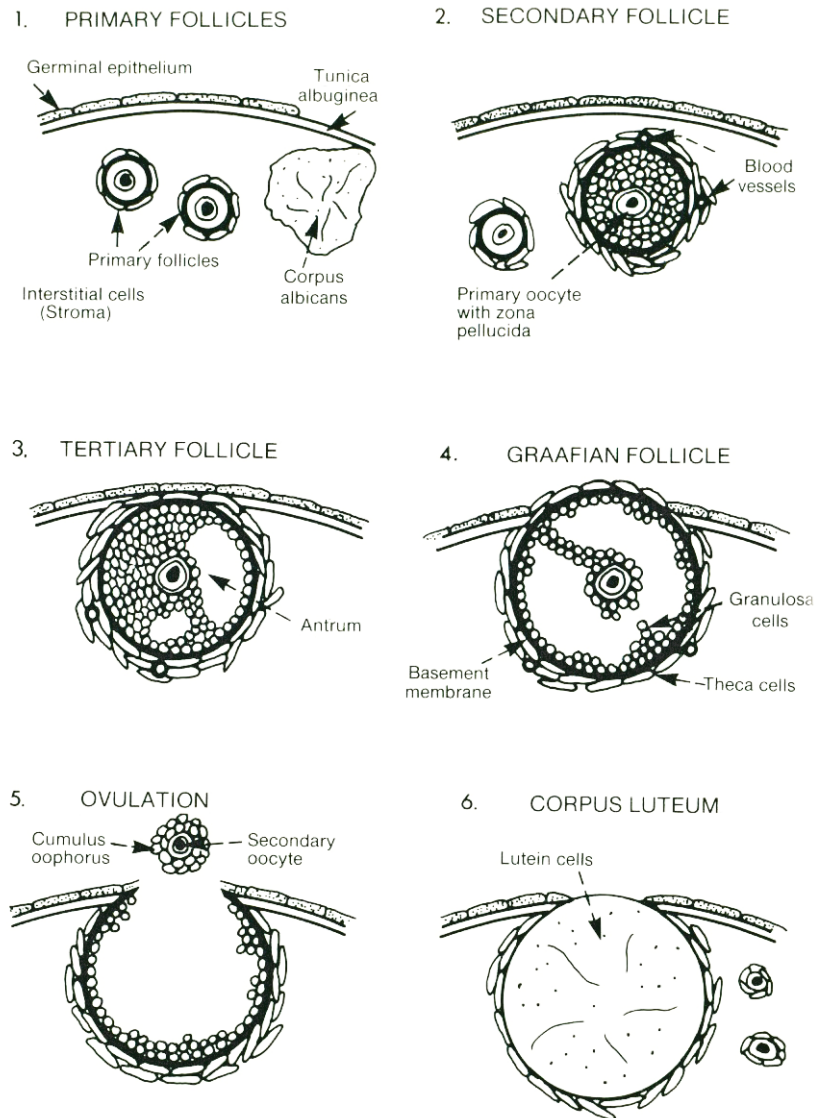
Before the breeding season, ovarian function starts working without any ovulation cycles or with some ovulation ones that are asymptomatic (anoestrus) and accompanied by the formation of corpus luteum, which lasts for a short time. Oestrus occurs only in those cycles which are followed by a fully functional corpus luteum. The ovulation number is variable, only few ovulations occur in the beginning and at the end of the season, while there is a lots one in the middle of the season. Ewes with adequate body condition have more ovulations during the season, than those ones which have poor or overweight body condition. The ovarian function is the most active in autumn or early in the winter, and then becomes less active. In spring months, ovarian function becomes active again, so ewes are ready for the reproduction. The season of autumn or early winter is called main breeding season, the season of spring is called secondary breeding season.

The implantation of embryos and the pregnancy need a fully functional hypothalamus, so the season of autumn is the most appropriate for embryos to survive.

Oestrus (ovarian) cycle

The cycle usually lasts for 16-17 days.

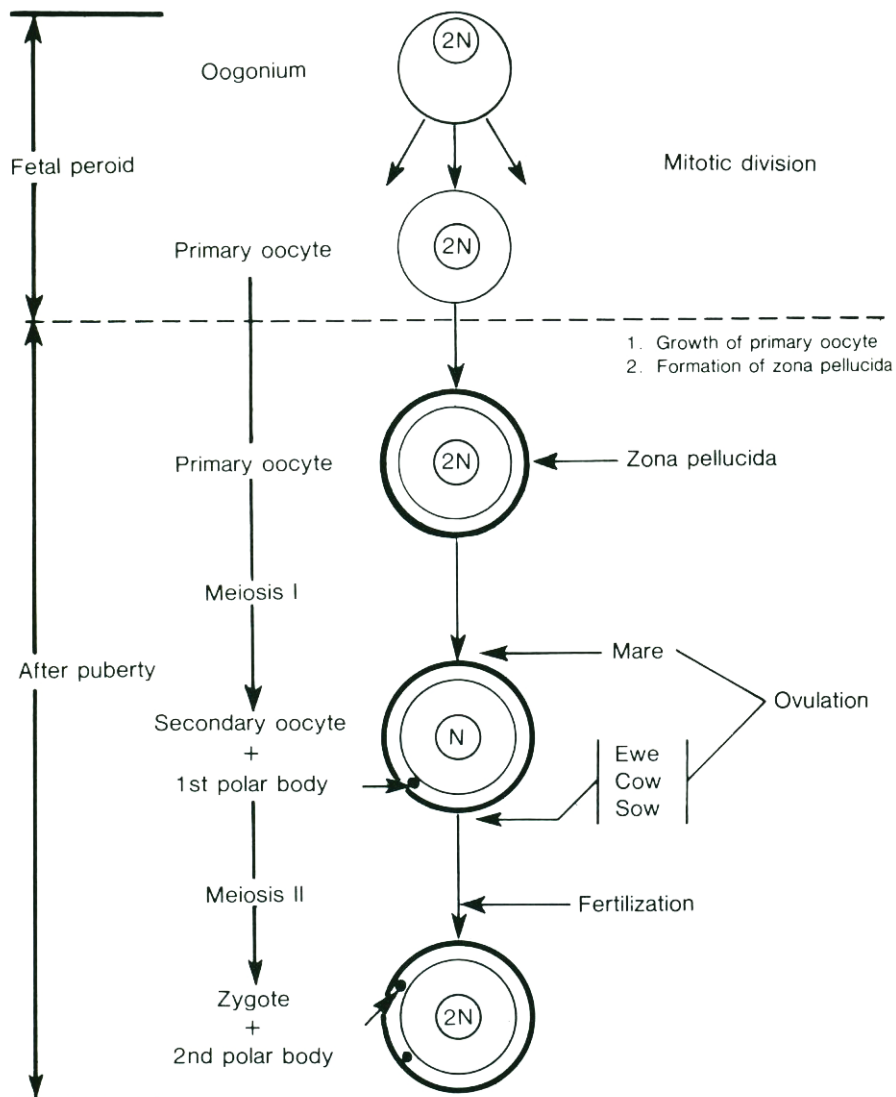
Follicles, which became enlarged during the corpus luteum phase, become atretic. On the 13rd-14th day the corpus luteum stops producing progesterone in unimpregnated animals by the effect of PGF₂_{alfa}. A wave of follicle development starts up in the ovary by the effect of the FSH trop hormone. These follicles grow from the size of 2 mm to 6-12 mm within 2 days by the effect of the increasing production of 17-^bestradiol and provide the follicle cycle. On the 15-16th day of the cycle LH hormones arrive from the hypothalamus instead of FSH hormone. At this time animals start exhibit signs of oestrus and follicles begin to prepare for ovulation. This LH phase is called ovulation LH wave.



*Schematic representation of the growth, development and luteinisation of ovarian follicles
The figure shows how follicles develop to the point of ovulation (1–4.). At ovulation (5) the mature oocyte is released and the Graafian follicle becomes transformed into a corpus luteum (6)
(from Ref. 1: Figure 6.1)*

The ovulation occurs between 2 hours before the end of oestrus signs and 8 hours after its end (it is around the end of the oestrus). At this time, ruptured follicles release the eggs and the **corpus luteum** develops from the **ovulated follicle**. If the animal becomes impregnated, the corpus luteum

will persist till the end of the pregnancy. That is why it is called **corpus luteum of pregnancy**. This will produce a huge amount of **progesterone** until the lambing.



Principal maturation stages for the germ cell during ovigenesis

- During the fetal period mitosis of oogonia is completed and meiosis I starts*
 - Meiosis I is arrested shortly after birth at prophase I*
 - Growth of the oocyte and formation of the zona pellucid are followed closely by growth of the follicle*
 - The preovulatory surge of LH initiates a resumption of meiosis*
 - Meiosis I is completed but meiosis II is arrested at metaphase II*
 - During fertilization, meiosis II resumes and is completed with formation of zygote*
- (from Ref. 2: Figure 7.1)

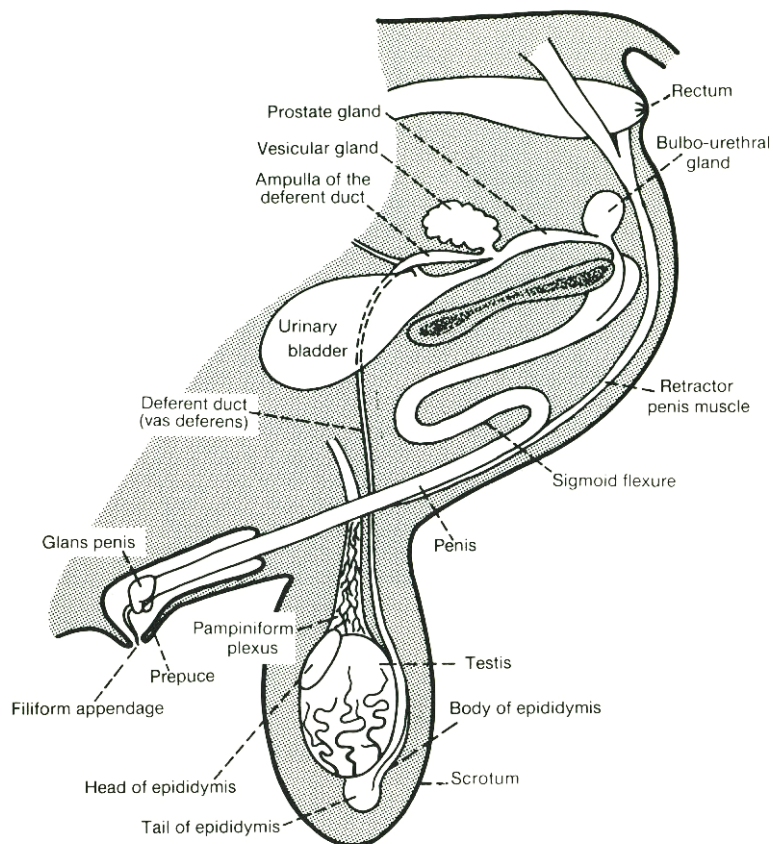
If the animal does not become impregnated, there is no need for the corpus luteum for a long time. This is called **cyclical corpus luteum**, which produce only a small amount of progesterone. Therefore, it is possible that the $PGF_{2\alpha}$ prostaglandin, produced by the healthy endometrium, may bring the functioning of the cyclical corpus luteum to stop, make it atretic, and then stimulate the follicles to develop again.

Oestrus

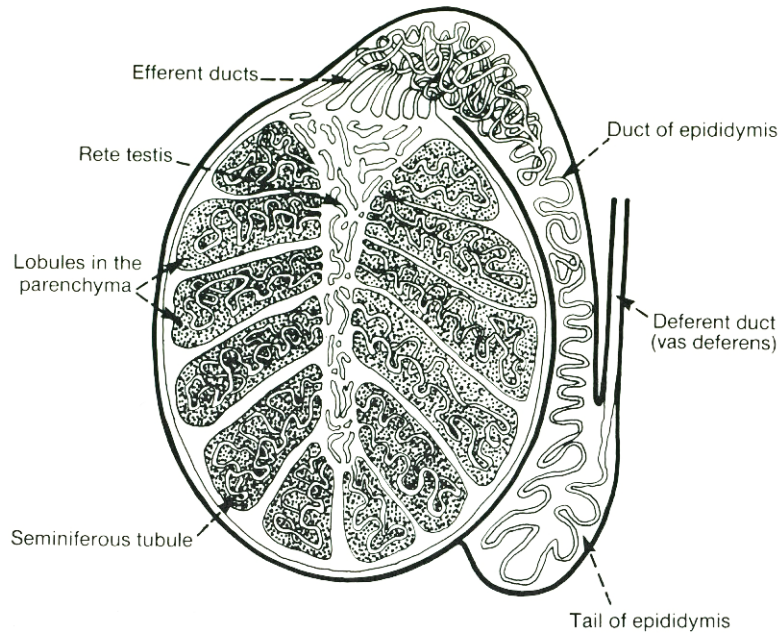
There are no visible pre-oestrus signs in sheep. However, rams are good at detecting ewes in heat by their smell of **vaginal secretion**. Ewes in heat do not mount other ewes. **The most typical signs** are that the ewe becomes remarkably excited, wags her tail vigorously and seeks out the ram intensely. If she finds a ram, provokes him and stands still for him to mount her.

At this time the vulva becomes swollen, flushed and the vaginal mucosa becomes bright red and hyperemic. The external orifice of the uterus is swollen, red and intrudes into the vaginal cavity. The cervical canal is opened and relaxed.

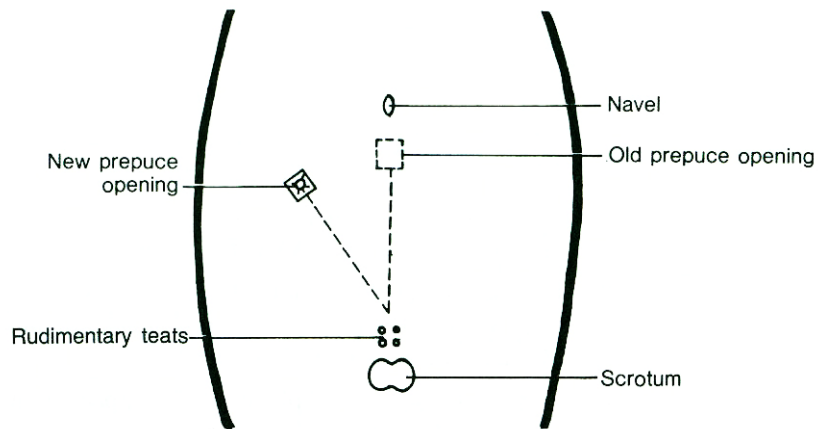
The most effective way to detect ewes in heat, if a teaser (an aproned, penis transplanted and vasectomised ram) is introduced.



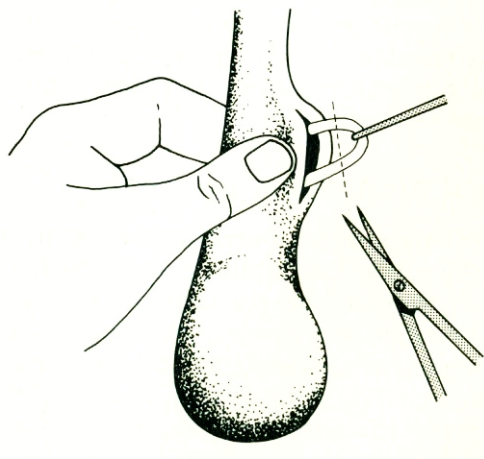
*The reproductive organs of the male
(from Ref. 1: Figure 2.1)*



*Cross section of a testis
 (from Ref. 1: Figure 2.2)*



*Redirected prepuce procedure
 (from Ref. 2: Figure 18.9)*



*Schematic representation of vasectomy
The section to be removed is indicated by the broken line
(from Ref. 1: Figure 8.1)*

The oestrus is very intensive in the beginning, and lasts for 8-12 hours. Later, oestrus signs become less intensive and cease gradually at the end of the oestrus.

Oestrus signs start mostly between 4.00 a.m. and 11.00 a.m. and between 1.00 p.m. and 10.00 p.m.

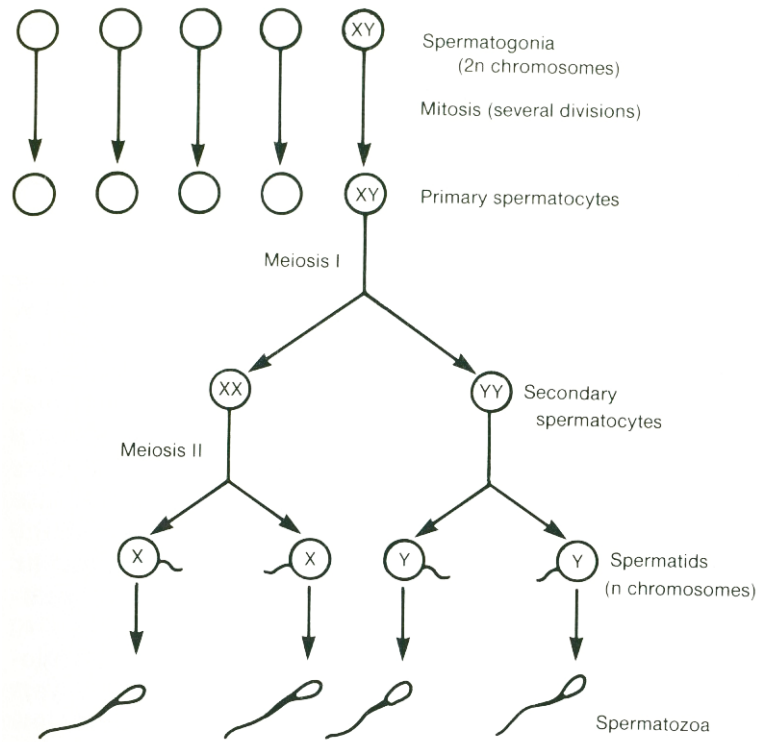
The **period** of oestrus lasts for 24-40 hours. This period of time lasts shorter in young ewes, than in older ewes.

Rams detect ewes in heat only by the smell of the **pheromone**.

The mating procedure is always initiated by the female sheep. The ewe seeks out the ram and starts pushing his head and hindquarters in a typical way, and then the ewe puts her head above the ram's neck. The mating preparation of the ram begins with the genital control (smell, taste). After it, the ram stamps with his forelimb and starts pushing the ewe by his head on her abdomen and around her shoulder. During this procedure the ram is emitting special voices.

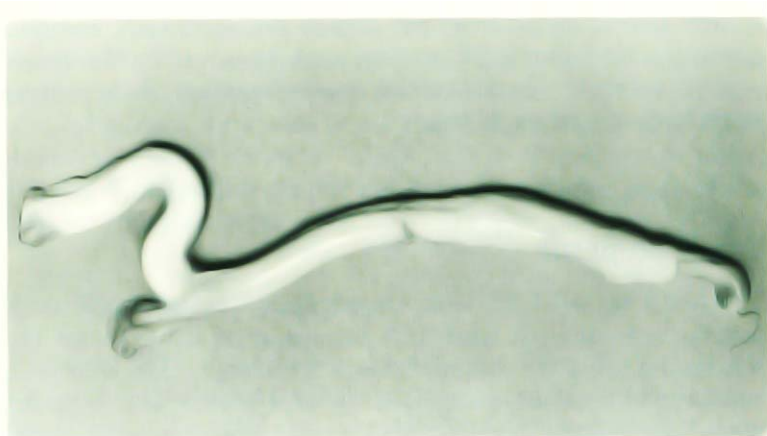
The ewe ejects some urine when the ram is approaching to her. The ram smells and tastes the urine and responds to this by curling his lip.

Before the mount, the ram puts one of his paws on the ewe's back. After it, the ram mounts the ewe without inserting his penis. The ram inserts his penis during the next mount, makes some very fast movements and ejaculates.



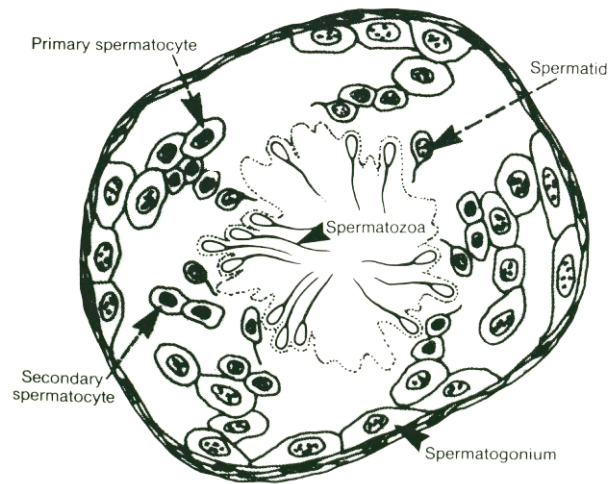
*Schematic representation of spermatogenesis
(from Ref. 2: Figure 6.2)*

Ram's sperms get into the vagina. They get across the cervix then the uterus and meet the ovulated egg in the oviduct. Sperms remain viable and fertile for about 24 hours in the vagina.



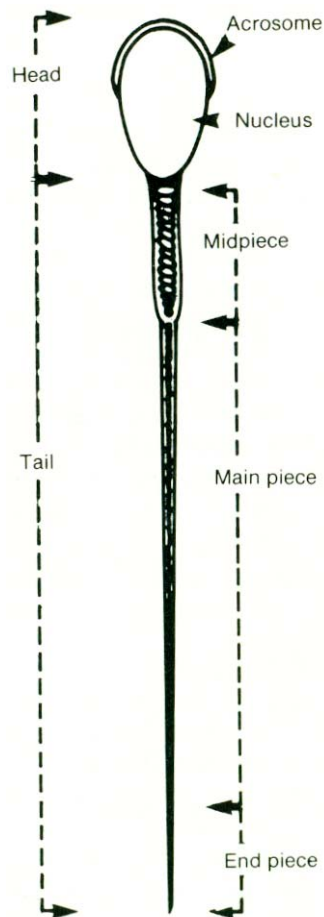
The penis of a ram

- a) The penis showing the sigmoid flexure; the retractor muscle has been cut*
- b) The tip of the penis showing the filiform appendage; the prepuce sheath has been drawn back*
(from Ref. 1: Figure 2.5)



*A cross section of a seminiferous tubule
(from Ref. 1: Figure 3.1)*

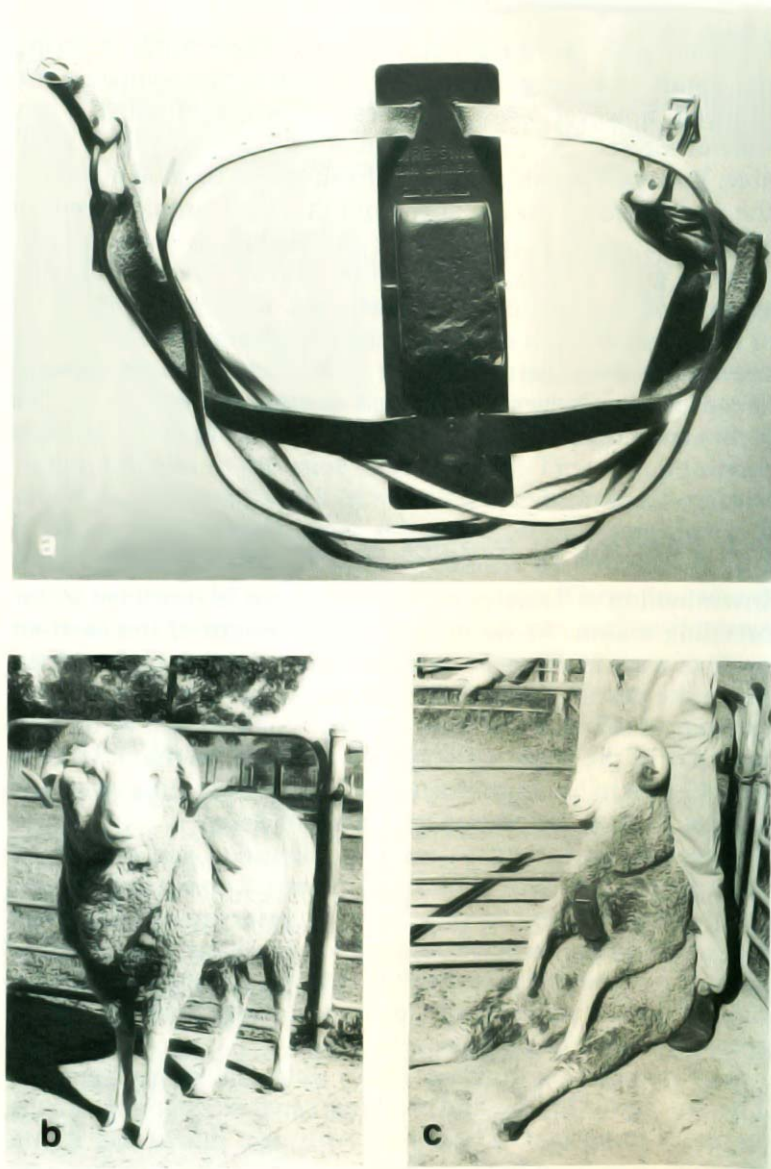
The conception result is good if the impregnation (with a ram or in an artificial way) occurs 4-36 hours after the beginning of the oestrus.



*Structure of a spermatozoon
(from Ref. 1: Figure 4.1)*

Embryonic death may be caused by environmental factors, such as heat stress, nutritional deficiencies, shearing, and treatments against internal or external parasites.

The embryonic loss is usually 2-4 % but 10-40 % may also occur, if keeping and/or nutritional conditions are not satisfactory.

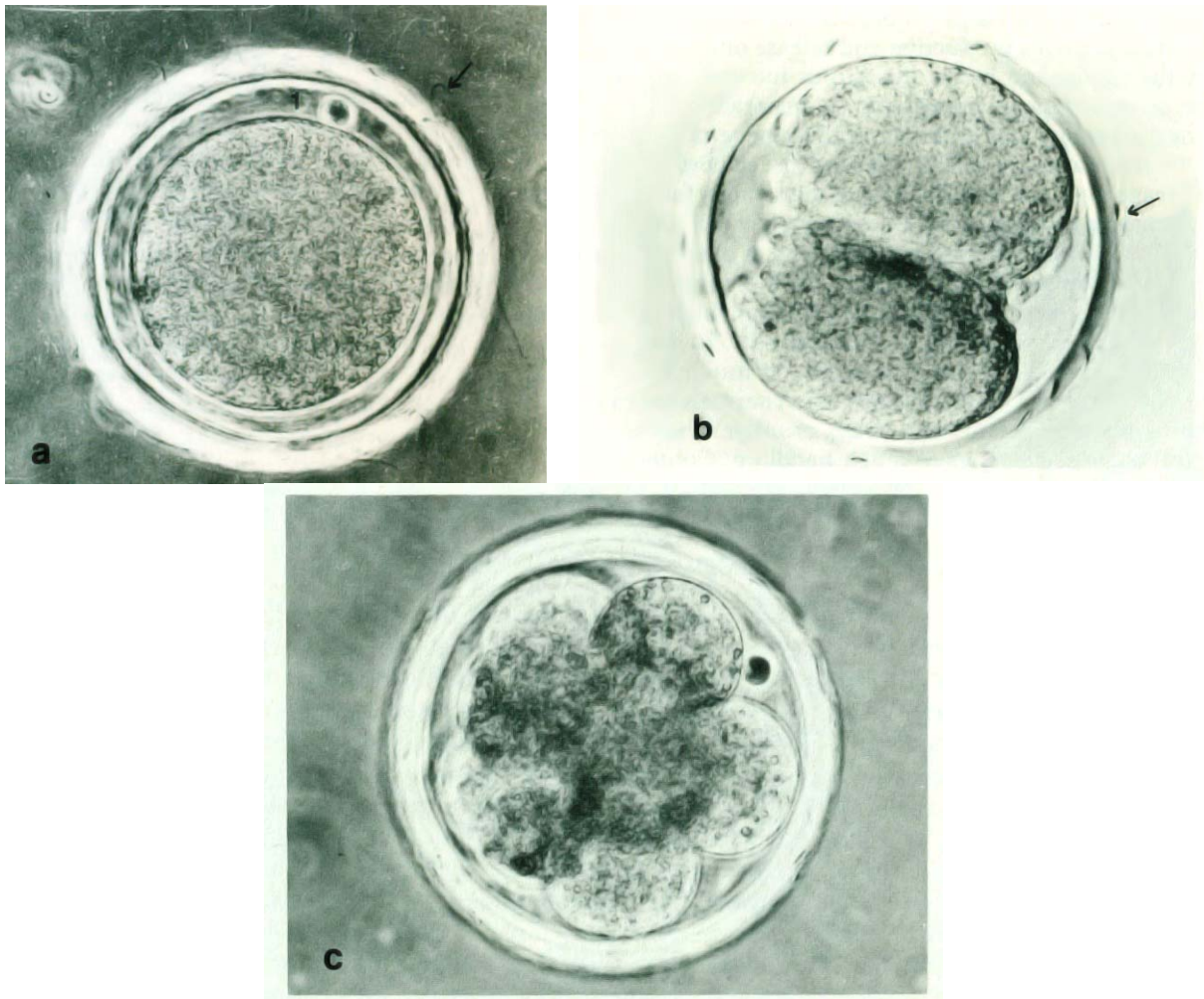


*A ram and harness
a) A Sire-sine harness; b) & c) A ram with the harness in place
(from Ref. 1: Figure 7.1)*

Determining sheep pregnancy

Determining pregnancy in time is important for the so-called accelerated reproduction, namely three lamb crops in two years, in order to reduce the time between two lambing. If the pregnancy test indicates that the impregnation has failed in a ewe, another attempt can be made together with the following group of animals.

Increased reproduction and more economical animal product production can be achieved by using the pregnancy test of sheep.



Development of the fertilized ovum

a) A sheep ovum with spermatozoa (indicated by arrow) attached to the zona pellucid. The first polar body is also indicated (1)

b) A 2-cell sheep embryo recovered on the day after fertilization (courtesy Dr. J.D. Murray)

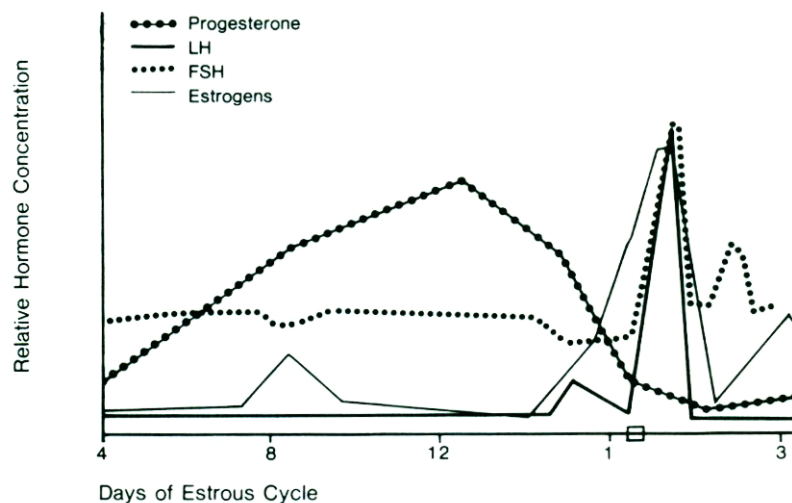
*c) A 3-day-old sheep embryo
(from Ref. 1: Figure 6.4)*

One of the ways to determine pregnancy is using teasers. Rams detect repeat breeders. This method should be used only in the main or the secondary breeding season. In practice, the ultrasound method is generally used.



A version of the ultrasonic sound equipment used to diagnose pregnancy in the ewe. Note wool has been from abdomen on front of udder (from Ref. 2: Figure 20.10)

Determination of the progesterone content of the blood can be done by a rapid test. In this case the result of the test becomes known on the spot. Since the ewe must be protected against stress, so taking blood sample between the periods of 17-20th days after the impregnation would be harmful (the implantation of the embryo usually falls on about the 15th day). The 30th day of the gestation is much better for this. If the progesterone level is between 11-13 nmol/l (it is between 7-8.5 nmol/l at ewe lambs) on the 30th day after the impregnation then the probability of the pregnancy is 95%.

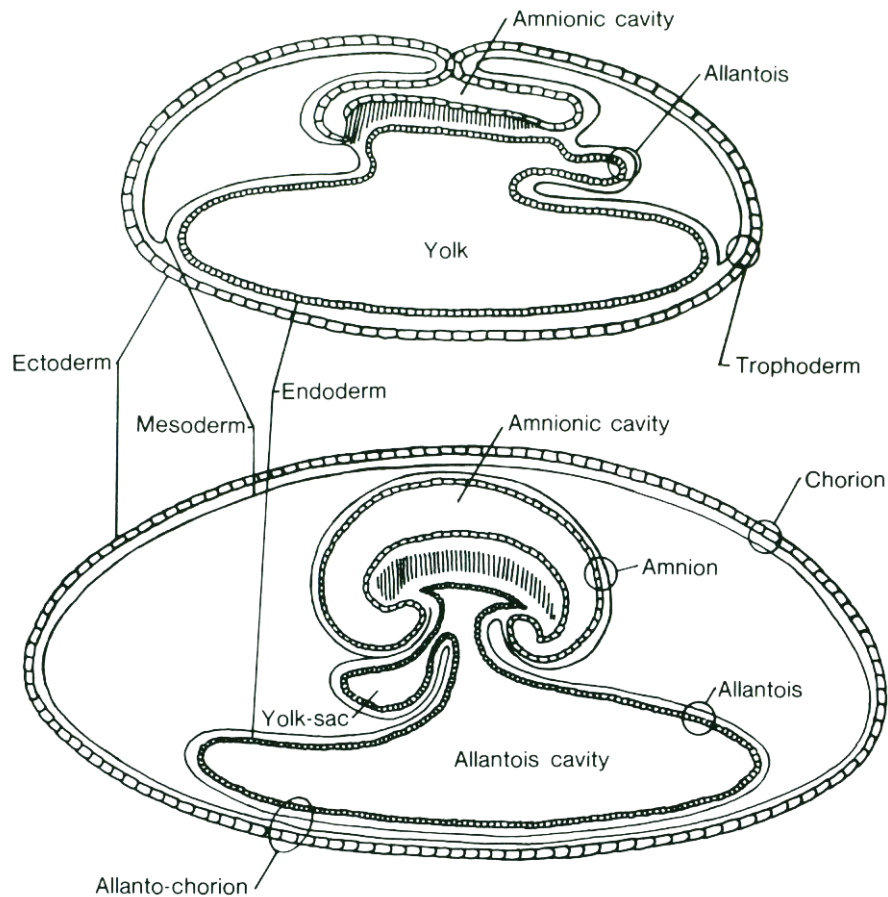


Hormonal changes in the peripheral plasma during the estrous cycle in the sow. Notable is the marked increase in FSH during metestrus (Based on literature) (from Ref. 2: Figure 5.2)

The progesterone level of animals, which are not pregnant, is low; this level is between 2-5 nmol/l in ewes with lamb, and it is between 0,5-2 nmol/l in ewe lambs.

The period of pregnancy in sheep

There are several factors, on behalf of the ewe, the ram and the foetus, that can have influence on the period of pregnancy (e. g. fast growing sheep breeds, special characteristics, nutritional condition, the sex and number of foetus(es) etc.).

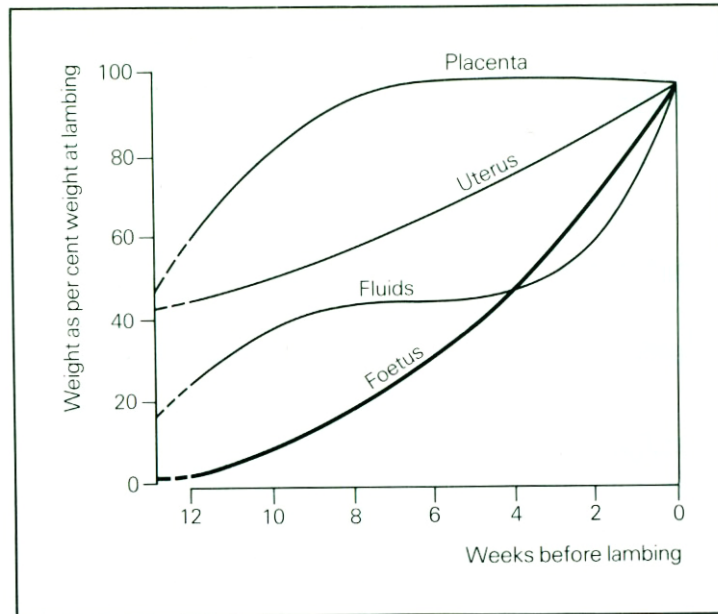


*Progressive development of the extraembryonic membranes including fusion of the chorioamnionic folds and the allantois with the chorion (Redrawn from Patten. 1964. Foundations of Embryology. McGraw-Hill)
(from Ref. 2: Figure 8.3)*

It is surprising that only 18-20% of pregnant animals lamb on the 150th day of the gestation, while 75-80% of them lamb between the 148th and the 152nd days. The remaining animals (21-25%) usually lamb between the 141st and 147th or between the 153rd and 157th days.

The gestation period of ewe lambs is usually one or two days shorter, while it is one or two days longer in older ewes.

Thus, the 150 days gestation period in sheep is an average. Gestation length is very useful to know, because it contributes to plan the optimal number of oestrus synchronization animal groups and to determine them according to age and to prepare for the lambing.



*The growth of the products of conception (from J.J. Robinson, I. McDonald, C. Fraser and M.J. Crofts (1977) J. agric. Sci., Camb. 88, 539-52)
(from Ref. 3: Figure 5.4)*

Getting ready for lambing

Before the lambing, one of the most important tasks is the foot care, or foot treatment if necessary.

Pregnancy ketosis may endanger pregnant ewes, so sudden change in quality or quantity of nutrition should not be done. Low energy feed (carbohydrate) should also be avoided.

When a ewe is getting ready to deliver her lambs, she will appear a bit hollow just in front of her hips, and she will be not as wide and full over the rump. Her vulva will become swollen and her udder will be distended. When birth-pains occur, the animal usually shows the following signs: ejection of some mucus discharge from the vagina, the ewe excitedly ferrets about a place, and lies down then gets up.

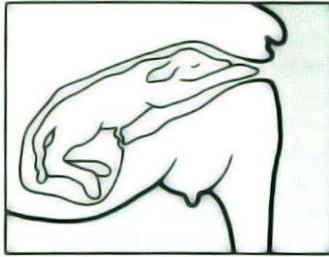
Approximately two days before lambing, there is a slight fall in body temperature.

The total length of the dilation and delivery pain is 10-18 hours.

The length of the delivery pain depends on the number of the foetus(es). Usually 30-60 minutes passes by between the deliveries of each lamb. The lambing will be finished, when the ewe calms down and expels the placenta.

The ewe should not be disturbed during the lambing process. If there is no trouble during the lambing process, human assistance is unnecessary, because it may cause birth canal infection.

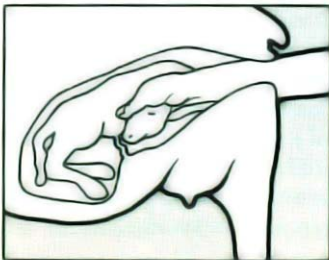
If some complications occur, veterinary assistance is necessary.



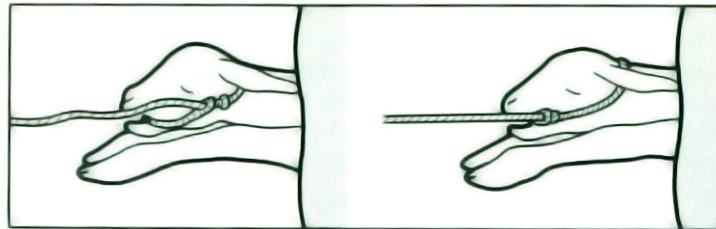
Normal presentation



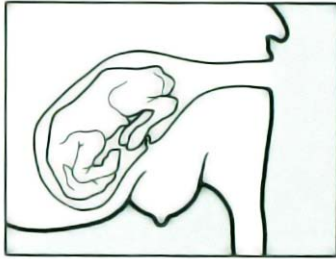
Forward presentation with one or both front legs back



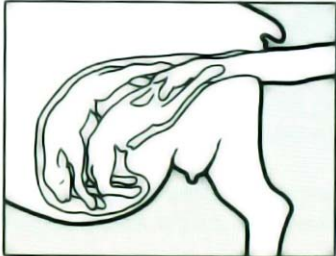
Forward presentation with head back



Use of a lambing cord



Breech presentation. The hind legs must be straightened before the lamb can be drawn



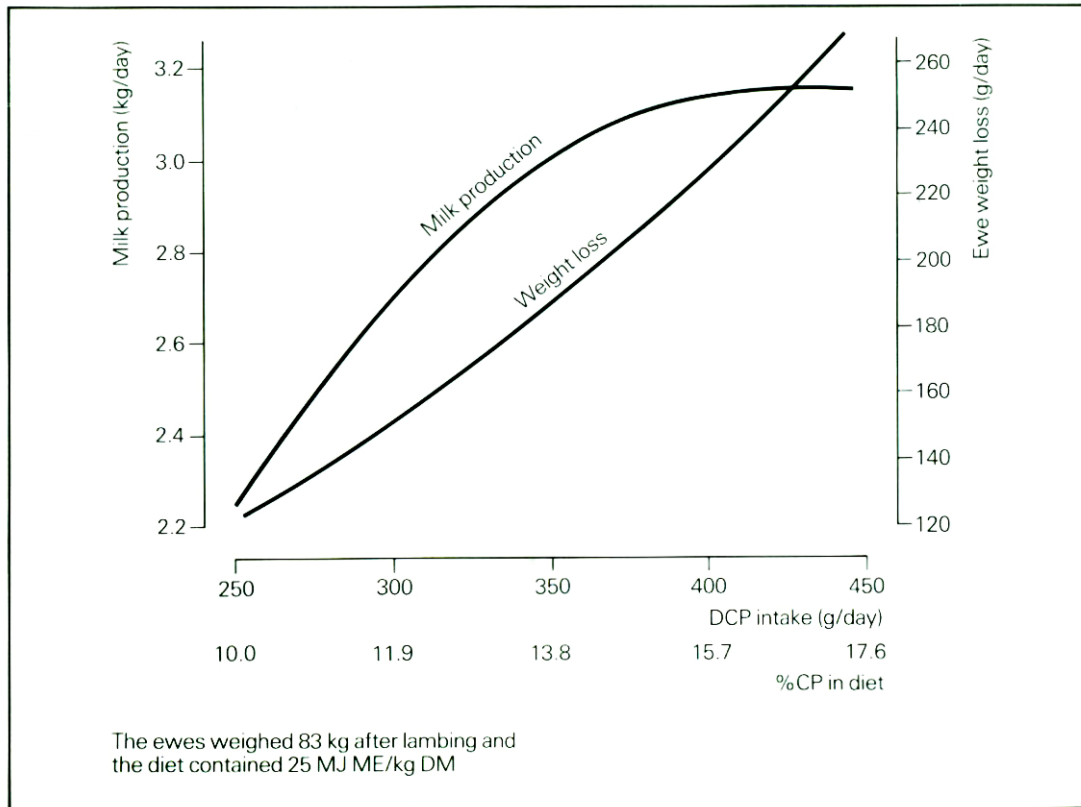
Where there are twins it is essential to identify limbs before attempting to draw the lamb

(from Ref. 3: Figure 6.3–6.8)

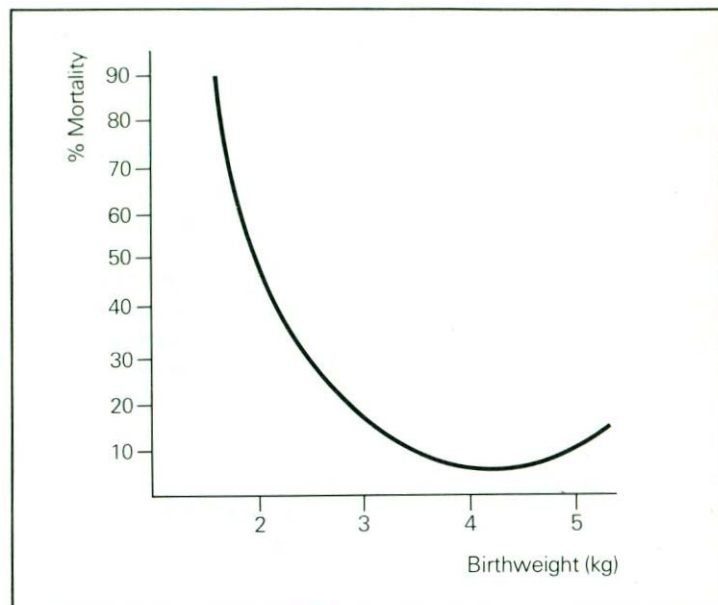
The umbilical cord will break on its own. If not, it should be cut and smashed within a few centimeter of the lamb's navel, and then dip into some disinfecting liquid.

The placenta is usually expelled 1.5-3 hours after the delivery of the last lamb. This process should not be accelerated by human assistance.

The newborn lamb is usually cleaned by its mother. If not, it may be necessary to wipe the lamb carefully. Right after it, the lamb should be nursed. There are some cases, when the newborn lamb cannot suck enough milk for some reason. At this time, it is necessary to find another ewe to nurse the lamb. If necessary, human assistance is needed to get the lamb sucking.



The effects of protein intake on milk production and liveweight loss in ewes receiving a high energy diet (from J.J. Robinson, C. Fraser and J.J. Gill (1973). Paper presented at the British Society of Animal Production Meeting. Harrogate, March 1973) (from Ref. 3: Figure 5.6)



The relationship between birthweight and mortality (from Ref. 3: Figure 6.9)

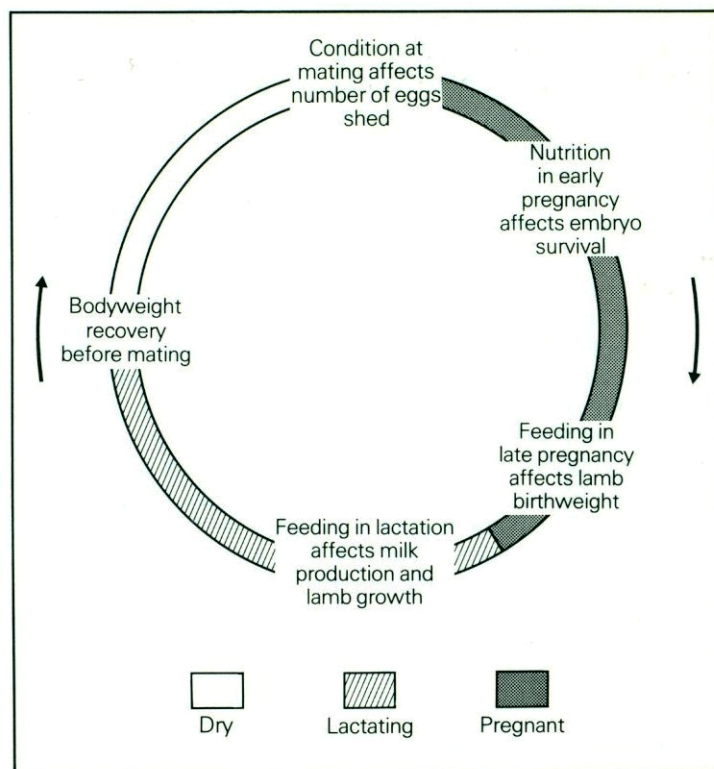
Involution of the genitals, biological basis of the reproduction

Involucional processes of the vagina and the vulva will be finished on the 10th day, horns of the uterus will become symmetrical on the 15th day after the lambing. On the 25th day, the formation and expulsion of lochia will be finished, the cervical canal will be closed and the endometrium will be cleaned up. The genitals will regain their original shape (morphological involution) on the 25th day after the parturition. Ovarian follicles are the largest in size and number between the 25th and the 33rd days after the lambing. The corpus luteum starts to flourish in autumn lambing ewes from the 25th day after the parturition.

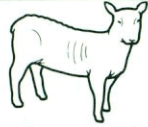
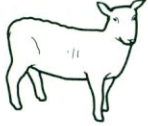
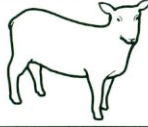
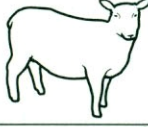
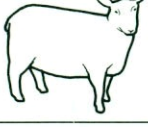
The complete (functional) involution will be finished on the 33rd day after the lambing.

The 75% of autumn lambing ewes' ovary start already functioning during the involucional process. The sexual function of winter or spring lambing ewes usually stops working for three month after the parturition. The reactivation of the ovary depends on the season, while the involucional process does not.

The involucional sexual apparatus needs about 30 day's recovery time, in order that the appropriate developmental conditions for the embryo(s) can be provided by the ovary.



*The annual cycle of nutrition and production of the ewe
(from Ref. 3: Figure 5.1)*

Score		Description	
1		Spine sharp, back muscle shallow, no fat	Lean
2		Spine sharp, back muscle full, no fat	
3		Spine can be felt, back muscle full, some fat cover	Good condition
4		Spine barely felt, muscle very full, thick fat cover	Fat
5		Spine impossible to feel, very thick fat cover, fat deposits over tail and rump	

*Body condition scoring
(from Ref. 3: Figure 8.1)*

The selection of the breeding stock, expanding the sheep population

The breeding success of sheep mostly depends on the quality of breeding ewes and rams. Animals, which have a low breeding performance and productive value, should be culled as soon as possible. If offsprings of sheep, which have the best breeding performance, are raised as breeding animals, then the value and profitability of the flock will show an increasing tendency. So, within a few years, the flock will be formed by the best blood lines that provide the opportunity for further breeding.

- **Selecting breeding ewes**

Ewes, which do not exhibit signs of oestrus due to a hormonal disorder, remain non conceived due to some organic degeneration, abort repeatedly, have an unviable foetus(es), remained unimpregnated for two breeding seasons or have only weak lambs, should NOT be selected.

Inheritance of multiple births is a family trait, so ewes with multiple births or those, which are descended from multiple births, should be preferred. Sheep's food intake grows bigger in the ratio of their weight, but their milk production does not depend on it.

Overbreeding should be avoided. Overbred animals should be culled. Yearlings become matured at the age of 5-9 months. If ewe lambs reach the weight of 33-35 (40) kilograms at the age of 7-9 months, then they can be impregnated.

A breeding ewe should not be replaced, until a better one is available. Young sheep should be culled, if they do not meet the requirements within 2 years.

Replacement sheep should be selected from quality ewes' (5-7 years old, healthy, have good reproductive performance and multiple births) offsprings.

Factors affecting sheep' ovulation number:

- sheep usually have 1-2 ovulation(s). Some species may have 3-5 ovulations (Romanov, Finnish Landrace);
- the condition of sheep is in close connection to the occurrence of multiple ovulations at the time of impregnation. Each additional kilogram in sheep's body weight increases their ovulation rate with 2-2.5%
- the ovulation number is higher during the autumnal impregnation, than during winter or spring;
- if a ram is introduced to ewes, then the ovulation rate becomes higher and the length of the breeding season becomes extended;
- ewes aged of 5-7 years have the most multiple births.

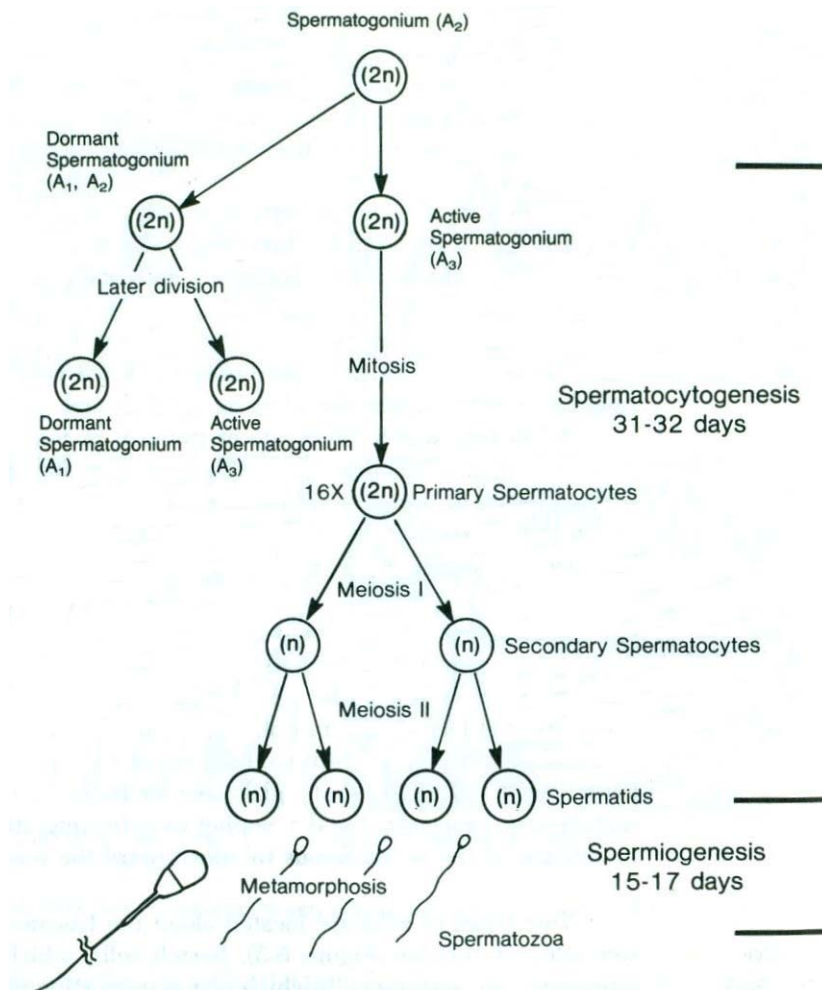
The progesterone level correlates to the pregnant animals' condition. The number of the pregnancy corpus luteum and fetuses is less variable in well nourished ewes, than in sheep with weak condition. The length of the gestation will not be extended in case of multiple foetuses (on the contrary, it will be shorter).

In healthy sheepstocks, which produce economical sheep products, the

- oestrus rate is between 94-96%,
- conception rate is between 91-95%,
- birth rate is between 90-95%,
- progeny rate is between 130-160 (180)%,
- breeding rate is between 94-96%
- gross lamb growth is between 130-150%
- net lamb growth is between 120-140%

- **Selecting breeding rams**

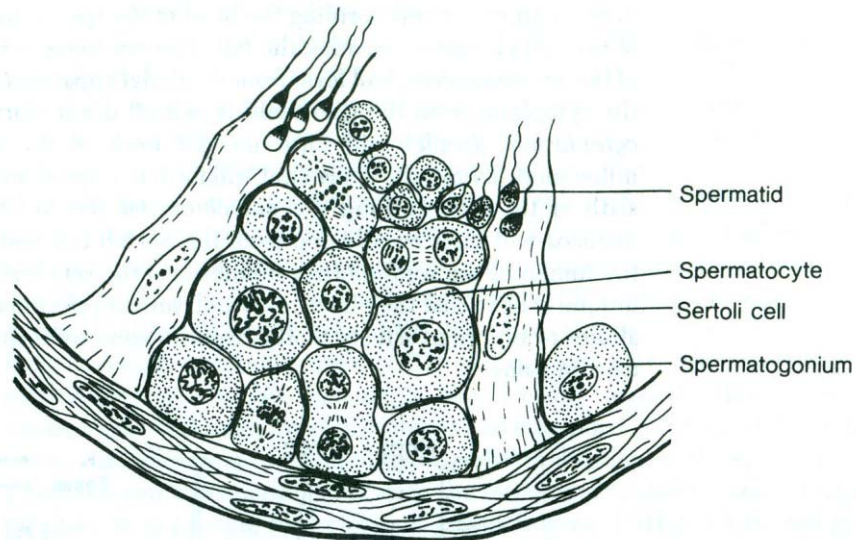
The selection of rams for service must be done under strict conditions, because this decision will determine the quality of hundreds of offsprings provided by the ram per year. It depends on the value of the ram that can be higher or lower, than the population average.



Spermatogenesis indicating the sequence of events and time involved in spermatogenesis in the ram

- a) An A_2 spermatogonium divides by mitosis, forming an active spermatogonium (A_3) and a dormant spermatogonium (A_1)
- b) The active spermatogonium undergoes four mitotic divisions, forming 16 primary spermatocytes
- c) Each primary spermatocyte will undergo two meiotic divisions, forming for spermatids (a generation of 64 spermatids from the A_3 spermatogonium)
- d) The dormant spermatogonium (A_1) will later divide to yield A_2 spermatogonia which through mitosis from new active (A_3) and new dormant (A_1) spermatogonia
- e) Each spermatid undergoes metamorphosis to form a spermatozoon (One spermatozoon is enlarged to permit more detail in morphology)

(from Ref. 2: Figure 3.2)



*Small segment of an active seminiferous tubule showing the developmental stages that occur during spermatogenesis. Note the concentric layers of spermatogonia, spermatocytes, and spermatids progressing from the wall of the seminiferous tubules to the lumen (Redrawn from Patten. 1964. Foundation of Embryology (2nd ed.) McGraw-Hill)
(from Ref. 2: Figure 6.3)*

If the ram has small testicles or signs of inflammation (adhesions, crusts, swellings) appear on his scrotum or testicles then should not be selected for service. The scrotal circumference of breeding rams should be more than 30 centimeters. Typical secondary sexual characters need to be appearing in breeding rams, such as short, wide head, wrinkled nose bridge, deep and wide chest. The appearance of the ram should be brave and determined.

The breeding ram's body weight should be 20-50% more than the breeding ewe's. Rams with low body weight will produce offsprings with similarly low weight, while rams with high body weight will produce lambs with high weight.

Ram lambs aged of 1 year can already be used as breeding animals. Rams usually should be culled at the age of 5-6, maximum 7-8 years. Inbreeding should be avoided when old rams are used.

The ram is high quality if his excellent characteristics will appear in his offsprings.

Behavioural and biological characteristics

Behavior is defined as an animal's response to its environment.

Sheep are agile, easily lay down and stand up. After having finished eating, they drink then find a shady place to rest. Lying animals place their front legs under their body and having a rest on their side. While sleeping they put their head on their front legs. Rams and pregnant ewes like relaxing on their side with their legs stretched.

Sheep usually prefer to stand with their back to rain, snow or wind. In mild weather they like grazing in the wind's eye. Sheep may walk 4-5 kilometers per day while they are grazing. A

stress free flock is not afraid of guardian dogs, a sudden noise will not frighten them and will not band together.

A group of 2-6 sheep is usually necessary for sheep to display their normal flocking behavior, but sometimes they like grazing alone. Sheep prefer to graze in the morning or in the evening rather than in the daytime. They need 4-6 hours per day to graze, drink, relax and chew the cud. Animals in light sleep usually make 80-100 chewing movements per minute during rumination. Rumination may take 6-12 hours a day, which needs silence and calmness. Rumination needs more time, if hay or dry forage is fed.

As protection against heat, sheep place their head under other sheep's abdomen. The major part of lambing occurs early in the morning, minor part of them occurs in the morning.

In case of pasture lambing, the ewe, which prepares to lamb, is usually excited, lies down, gets up, tries to find an appropriate place and then hide away. After having known each other, the ewe returns to the flock with her lamb(s). In case of shed lambing, the ewe, which is ready for lambing, should be placed into the lambing barn.

The social hierarchy of sheep is not so determined, as of other animal species. Ewes and lambs may conflict with each other. At this time they clash head to head. Fighting often occurs between rams and ram lambs, especially during the breeding season. Sheep usually defecate 6-8 times and urinate 8-10 times a day.

Sick animals can be easily detected during feeding. They should be separated and/or treated.

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