Agricultural Innovation Program for Pakistan (AIP)

A training manual on artificial Insemination in goats

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A training manual on artificial insemination in goats

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Preface and acknowledgements

South Asian countries, notably Pakistan, being one of the centres of livestock domestication are endowed with diverse livestock genetic resources, in particular goats and sheep. Better genetic management (i.e. improvement and conservation) is key to sustainable utilization of such genetic diversity. Traditionally in Pakistan, every year, millions of genetically "superior" indigenous bucks and rams with faster growth rates and potential for higher carcass yields are castrated before they reach breeding age, thus are unable to transmit such genetic superiority to the subsequent generations. This is a routine practice by farmers involved in rearing goats for 'Eid' sacrificial purpose and leads to continuous negative genetic selection. This practice is undesirable in the long run, as it has resulted in scarcity of quality breeding bucks.

With the objective of sustainably conserving the genetic diversity in goats and chicken in Pakistan, and other three Asian countries, ILRI executed Global Environmental Facility (GEF) funded project titled "Development and application of decision-support tools to conserve and sustainably use genetic diversity in indigenous livestock and wild relatives". The project is implemented by United Nations Environment Programme (UNEP) and started in 2009. Through this project several awareness creation activities organized by the University of Agriculture (UAF) Faisalabad were conducted among farmers and policy makers. Specifically, national and provincial goat shows and breed shows were organized during which farmers registered their goats, which were then objectively assessed for economically important traits and then ranked.

As a follow-up to above efforts and as part of a strategic and long-term strategy to ensuring sustainable availability of good quality breeding males, ILRI together with UAF developed the goat AI manual and launched the first 'hands-on' training on 'Artificial insemination in indigenous goats' using the manual. The development of the manual and the training was supported by the 'Agricultural Innovations Program (AIP) for Pakistan led by CIMMYT and funded by USAID, and the livestock component of which is led by ILRI. Initially, 24 master trainers from Punjab, Sindh, KPK, Balochistan AJK and Gilgit-Baltistan were trained on AI using the manual.

The authors gratefully acknowledge the University of Agriculture (UAF) Faisalabad for organizing the breed promotion shows and awareness activities, and the AIP, GEF and UNEP for funding and supporting these activities and specifically, UAF for providing the logistic support that enabled the success of the awareness creations and training events.

Introduction

Reproduction is critical to attainment of profitability in any livestock enterprise, including goat rearing. The breeding program on the farm will play a key role in the attainment of reproductive efficiency. Various assisted reproductive technologies have been applied to accelerate the genetic gain and enhance reproductive performance of various livestock species. In goat rearing, Artificial Insemination (AI) is currently the most practical technology for optimizing reproductive efficiency. AI accelerates the rate of genetic gain within a herd, maximizes the number of offspring from a desirable sire, enables genetic exchange over wide geographical areas, and also allows use of genetic material from incapacitated sires or those no longer alive if their semen had been preserved. AI is an acquired technique which when skillfully utilized based on knowledge, is practical to use and results in good success. The goat artificial insemination training manual is useful for AI technicians, herd managers and animal health service providers in the livestock sector. It is designed to complement classroom training as well as a refresher manual for service providers in order to optimize breeding and reproductive performance of dairy goat herds for improved productivity.

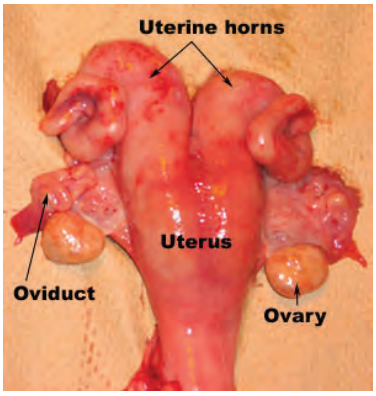
Anatomy of the reproductive tracts

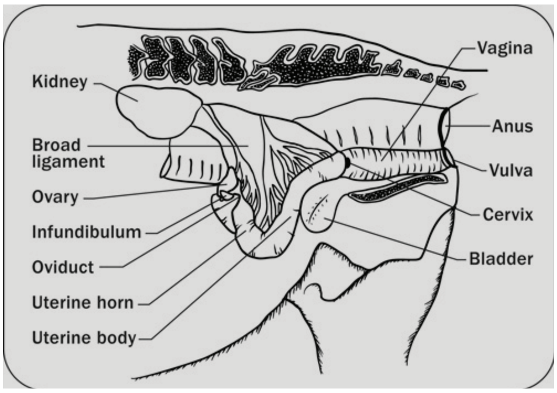
Successful artificial insemination depends on the understanding of the organs involved in reproduction, in order to know where to deposit semen for optimal conception rates.

Female reproductive tract

The vulva is the visible exterior segment of the reproductive tract, located beneath the tail and immediately below the anus. It consists of two vertical lips or labia. It is the entry to the female reproductive tract during copulation. Apposition of the moist vulva lips together with its sphincter form a physical barrier that prevents entry of foreign material and contamination of the female reproductive tract. When the doe is on heat the vulva may be swollen, reddened and mucus may be seen coming through the lips.

Figure 1. Structure of the female reproductive tract.





http://www.omafra.gov.on.ca/english/livestock/horses/facts/10-099.htm

Anterior to the vulva is the vestibule, at the base of which is the clitoris and urethra where urine exits through. During AI one has to be careful not to introduce the AI pipette into the urethra.

The vagina is directly in front of the vestibule. It is a tubular structure and is the organ of copulation where the buck deposits semen during mating.

Cranial to the vagina is the cervix. Compared to the rest of tubular genitalia, it is a firm structure and forms the joint between the vagina and the uterus. It is about one to one-half inches long, contains about five cervical rings or folds, and is referred to as the neck of the uterus. It is usually closed to create a physical barrier that prevents foreign objects from entering the uterus. During pregnancy, a thick mucus plug closes the cervix to keep out material from entering the uterus and thus safeguarding the pregnancy. When the doe is on heat the cervix opens and secretes mucus to allow for movement of spermatozoa to the site of fertilization. This opening of the cervix during oestrus is the one that allows passage of the insemination pipette through the cervix in order to perform AI. At the end of pregnancy the cervix will fully open to allow for delivery of the kid.

After the cervix comes the uterus. It consists of a small uterine body and two separate horns (cornua). It is the organ that houses the growing fetus during pregnancy and also produces substances (hormones) that are involved in the regulation of the reproductive cycle.

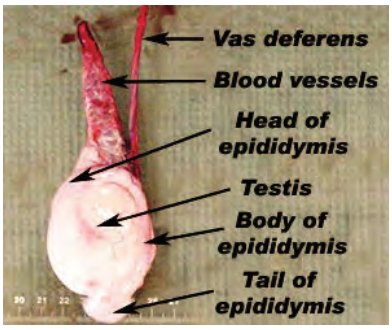
Oviducts project from the front end of each uterine horn. Each oviduct is a thin tubular structure and is a conduit between its ovary and uterine horn. The oviduct is the place where fertilization takes place. At its tip, the oviduct opens like a funnel (infundibulum) near the ovary. The infundibulum is the structure that receives the ova released from the ovary, directs them to the opening of the oviduct for transport to the site of fertilization.

The ovaries are the innermost structures of the reproductive tract. They produce the egg (ovum), and also the hormones that are responsible for oestrus and maintaining pregnancy. From puberty on throughout the reproductive life, the ovary contains follicles (fluid filled structures in which the ovum develops and is suspended) and a corpus luteum (a temporary structure formed by a ruptured mature follicle that has released its ovum). The fluid inside the follicle is rich in the hormone estrogen. At a particular time, the follicle ruptures to produce the egg, in a process referred to as ovulation. After the follicle has ruptured and released the egg, a yellow body, the corpus luteum, develops at the site of the ruptured follicle. It is a structure that grows rapidly on the ovary and then undergoes lysis (death) after some days if the doe does not get pregnant. The corpus luteum produces the hormone progesterone, which regulates the oestruscycle and is also responsible for maintenance of pregnancy. See http://www.omafra.gov.on.ca/english/livestock/horses/facts/10-099.htm for the structure of the female reproductive tract.

Male reproductive tract

The visible parts of the male reproductive tract are scrotum, prepuce and penis. The scrotum is the muscular sac hanging between the hind legs and it contains the testes, which are the paired male gonads. The scrotum supports and protects the testes and plays a major role in temperature regulation. It maintains the temperature of the testes at 3 to 5°C below body temperature for optimal functioning of the testes. The testes produce the male gametes (spermatozoa) and secrete the male sex hormone, testosterone. Testosterone is required for the development of the male sexual characteristics, maintenance of normal sexual behavior and sperm production. The penis is the organ of copulation which allows the buck to deposit semen into the vagina of the doe. At the tip of the penis is a thin tubular structure, the urethral process, which sprays the semen in and around the cervix of the doe. The penis is covered by the prepuce, a fold of skin which protects it. Please see http://www.extension.org/pages/19265/anatomy-male-anatomy#.Uvo7BGLViAg for anatomy of the male reproductive tract.

Figure 2. Abattoir specimen showing parts of the buck's reproductive system.



The other parts of the male reproductive tract are the accessory glands, which are not externally visible. They are the seminal vesicles, prostate, bulbourethral glands and ampulla. They add fluid to the sperm, together forming semen, which is the one produced by the buck during mating in a process referred to as ejaculation. These fluids contain sugars which nourish the sperm, provide buffers hence prevent rapid changes in pH, and other chemicals that protect and propel the sperm through the male reproductive tract during ejaculation. The vas deferens is the duct through which sperm moves from the testes to the urethra. The amount of sperm in an ejaculate and the volume of the ejaculate depend on the season, age of the buck, level of sexual activity, breed and the individual buck itself. A normal range of ejaculate volume in the buck is 0.5 to 1.5 ml, containing 1.5 to 5 billion sperm per ml of ejaculate.

Practical activities:

- As part of the practical session for the above, female and male reproductive organs in live animals and abattoirs specimens are examined and used to illustrate or explain the functional anatomy of the different parts of the reproductive system.

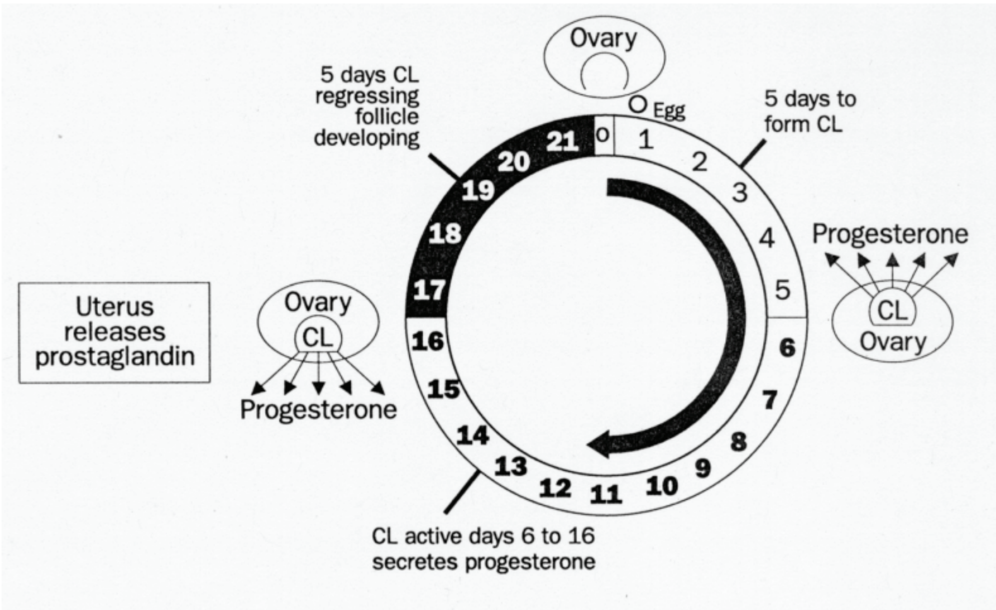
Female reproductive cycle

Young female goats or doelings reach puberty at about 6 to 8 months of age and may be bred at 7 to 10 months of age depending on how they have been fed and grown. Puberty is the stage of sexual development at which the doe is capable of getting pregnant, if it is mated. Various factors affect the onset of puberty, including, healthcare, nutrition, season of birth and breed. Poor nutrition delays puberty; smaller breeds of goats attain puberty earlier; whereas kids born during the season when feed is plenty and of good quality attain puberty earlier. Breeding of does for the first time should be based on body weight as proportion of mature weight, and not age at which puberty is attained. It is recommended that young females should be bred after they have attained 60 to 70% of their adult weight to ensure kidding ease and avoid dystocia. Puberty is more dependent on body weight than age, so breeding should not be done until the right weight is attained.

The oestrus cycle

Once puberty is attained, the doe comes on heat (oestrus) at regular intervals thereafter. Oestrus is associated with the desire to be bred. This behavior (oestrus) is repeated at regular intervals, unless interrupted by pregnancy or disease, and this repetition is referred to as the oestruscycle. Therefore, the oestruscycle is defined as the number of days between two consecutive periods of oestrus.

Figure 3. Schematic representation of the oestruscycle.



A healthy doe will come into oestrus every 20 to 21 days, except when pregnant. In different individuals and breeds, however, the oestruscycle length can range between 17 to 25 days. To help determine the oestruscycle length of each breeding doe, the producer should maintain a breeding diary or records. Good records are important for informing a breeding program, as they can help the breeder predict when a doe is likely to come on heat, and thus enable more careful observation for heat signs at that time. Additionally, good records will help determine if a doe has a problem, if she comes on heat too early, delays, or fails to come on heat at the expected time and she has not been previously bred.

When does are on heat, they exhibit various physiological and behavioral changes, referred to as signs of oestrus. These signs of heat are:

- Bleating continuously
- The vulva may become swollen, reddened and may appear moist, dirty or muddy due to mucus discharge from the reproductive tract
- There is frequent twitching of the tail
- She may urinate small amounts of urine frequently
- A clear, stringy mucus discharge may be seen from the vulva (may mat hair in perineal area)
- The doe displays restlessness
- She may mount other goats and stand to be mounted

The doe may not exhibit all the above signs, and under adverse conditions, such as extreme heat and injuries, may not show any signs at all. Standing to be mounted is the most obvious or accurate sign that a doe is on heat. Standing to be mounted will be enhanced in the presence of a buck. Does not in oestrus will always resist mounting attempts by the buck or other does. Standing oestrus in does may last for 12 to 36 hours.

Hormonal control of the oestrus cycle

Upon reaching puberty, every three weeks the doe's brain signals the follicle in the ovary to start developing the egg. The signal from the brain is from the hypothalamus which releases the hormone Gonadotropin Releasing hormone, or GnRH. This hormone stimulates the pituitary gland at the base of the brain to produce gonadotropin hormones, Follicle Stimulating Hormone (FSH) and Luteinizing Hormone (LH). Follicle stimulating hormone, as the name implies, initiates the development of follicles on the ovary from small pinhead sized structures to fluid-filled structures that are about half an inch in diameter. As a follicle grows in size, fluid accumulates in its cavity and secretes estrogen hormone. Estrogen is the female sex hormone. It is secreted into the blood stream and circulates throughout the body. Estrogen production is greatest when the follicle reaches its maximum size. High levels of estrogen act on the does' brain resulting in the changes in the doe that are manifested as heat signs. It affects the nervous system causing behavioral changes such as restlessness, increased vocalization, twitching of the tail, lack of appetite, desire to mate by standing to be mounted, and also affects the reproductive system by increasing blood flow to the reproductive tract causing swelling of the vulva, reddening of the vulva, and the mucus discharge seen from the vulva during oestrus.

Once estrogen levels from the mature follicle reach a certain threshold, they stimulate a peak release of LH (LH surge). The LH surge causes the mature follicle to undergo changes that result into its rupture and release of the egg. This rupture of the mature follicle and release of the egg is referred to as ovulation. After ovulation, the cells inside the ruptured follicle begin to grow and undergo changes (luteinization) under the influence of the gonadotropin hormone LH to form a gland called the Corpus Luteum (CL), the yellow body. The CL produces progesterone, the hormone of pregnancy. Its function is to prepare the uterus for accepting the fertilized egg, and to maintain pregnancy by preventing recurrence of the oestruscycle during gestation. If fertilization does not occur, the CL is destroyed at about 16 days after heat and consequently stops producing progesterone. Destruction of the CL is caused by the hormone prostaglandin F2α (PGF2α) which is produced by the inner wall of the uterus. The drop in progesterone concentration is consequently followed by a rise in gonadotropin release (FSH and LH), development of another follicle(s) and egg(s), and recurrence of heat about 20 to 21 days after the previous heat period. This cycle will continue throughout the reproductive life of the doe and will only be interrupted by pregnancy, disease, malnutrition or senility. See http://extension.missouri.edu/publications/DisplayPrinterFriendlyPub.aspx?p=MP735 for schematic representation of the oestruscycle.

When the egg is fertilized and accepted, the presence of the developing foetus in the uterus sends a signal to the dam causing the CL to remain active and produce progesterone for maintenance of pregnancy. This process is referred to as maternal recognition of pregnancy.

Heat detection

Heat detection is one of the factors that greatly determines the success or failure of any AI program. Under natural mating conditions, the buck accurately picks the does that are on heat, and if he is normal, promptly mates them. However, with AI, the inseminator replaces the buck. Therefore, for optimal conception rates to be achieved with AI, the doe has to be inseminated at the appropriate time, and thus it is important to recognize when a doe is on heat and to breed her at the right time. For a successful genetic improvement program and efficient delivery of superior genetics through AI service, good heat detection is therefore critical. It is recommended that a person be designated to observe animals in the herd for heat signs at least twice a day. Sufficient time (at least 15 minutes depending on herd size) should be allocated for the exercise, and it should not coincide with periods of activities, such as feeding, that would distract the attention of the animals. Preferably it should be done during the cooler parts of the day (morning and evening) when the animals are resting. Accurate heat detection greatly enhances the success of an AI program.

Oestrus detection techniques:

- Having a buck in close proximity to the does. Does in heat are more easily identifiable if a buck is housed nearby. The signs of heat will be more intense, and she will pace restlessly along the pen in an effort to try and get to the buck or she will stand close to the fence with the hope of enticing the buck.
- Time to observe heat. Animals tend to be more sexually active during the cooler parts of the day (around dawn and dusk) and this is a good time to observe for heat. Thirty minutes before morning feeding/milking and 30 minutes after evening feeding/milking should be used for heat detection. Putting a number of does together in one area or pen will facilitate the interaction between animals and make it easier to notice the heat signs.
- Using a teaser buck. This is a buck that has been prepared in various ways so that he can be able to pick out does that are on heat but cannot be able to make them pregnant. A teaser buck could be an entire buck with an apron or whole penis has been deviated, hence is able to detect and mount does on heat but whose penis will be unable to enter the female genitalia; it could also be a vasectomized buck, who will detect does on heat, mount and copulate with them but is incapable of depositing spermatozoa into the female reproductive system.
- Using a teaser with a marking harness. Markers will leave identifications on the ramps of does that stood to be mounted (were on heat). This way labor is saved as someone does not have to be with the herd to check for the does standing to be mounted. The marked does would be noted in the morning or evening each day.
- Anticipate heat with records. Using well-kept reproductive records, it is possible to predict when the doe would come on heat, thus enabling closer observation.

Figure 4. A buck for heat detection with an apron.

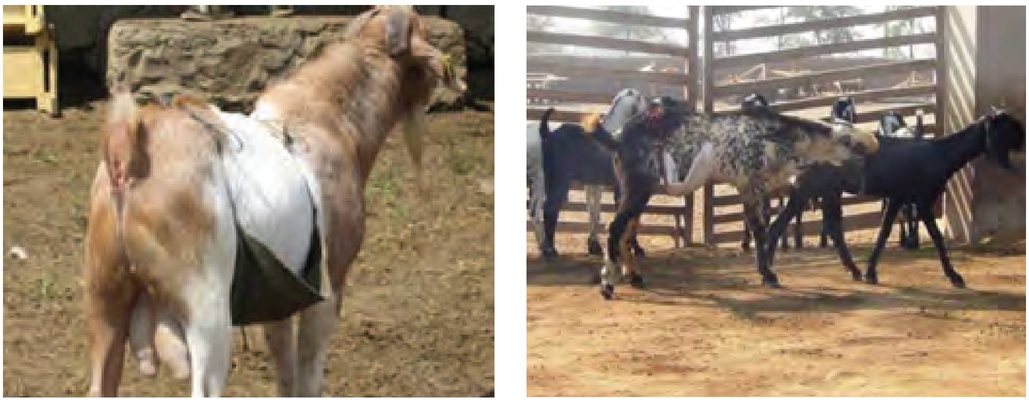


Photo courtesy of M.S. Khan

Practical activities:

Group discussion among trainees is facilitated on goat production, including the following:

- When does attain puberty; age versus weight
- Factors that affect onset of puberty
- Management strategies that can be utilized to enhance early onset of puberty
- Advantage(s) of enhancing early onset of puberty
- Age at first breeding
- Age versus weight as criteria for first breeding,
- What sexual maturity is
- Difference between sexual maturity and puberty
- How to tell a doe is on heat?

Trouble-shooting heat detection 3.0 Semen storage

Semen to be used for AI is collected from selected bucks, processed and safely stored. The processing includes dilution of the ejaculate with a semen extender in order to produce many doses from a given ejaculate. Cryo-protectant are added to protect the spermatozoa from being destroyed during the freezing process. The extended semen is then packed in labelled straws and stored frozen in liquid nitrogen in tanks at -196°C. At this temperature, the spermatozoa remain inactive but viable. Each semen straw contains the necessary number of spermatozoa for one insemination to be able to cause conception. The straw is labelled with information regarding the buck from which it was collected (sire code and breed), date of processing and semen processing station code.

Liquid nitrogen tanks (Figures 5, 6 and 7) are large metal vacuum containers used to store frozen semen. They come in different sizes and can store up to 100,000 semen straws for many years. The tanks are well insulated to help maintain temperatures at -196° C which is necessary for the semen to remain viable. At this low temperature, the metabolism of the sperm cells is stopped and they remain in resting state. The working parts of the tank are a lid, styrofoam cork, canisters, canes, the inner chamber that holds the liquid nitrogen, and a spider to keep the canisters from moving around. The cork is 4-6 inches in length with grooves on the sides for the canister handles. The cork fits loosely in the neck of the tank, allowing for the evaporating nitrogen gas to escape. If capped too tightly, the gas would build up pressure in the tank resulting in an explosion.

Canisters hang from the top of the tank supported by their wire handles which protrude to the outside at the top of the tank. The canisters are usually six in number and their long wire handles are used to lift the cylindrical end of the canister in and out of the tank. The canisters hold the canes that contain the semen straws. For ease of management of the semen inventory, the canister handle and/or the groove that supports it on the tank are numbered to facilitate quick identification of the semen straw that needs to be picked from the tank.

Figure 5. Liquid nitrogen tank (left), with lid open (center), showing grooved Styrofoam cork (right).

Figure 6. Wire handle raising the canister from the liquid nitrogen tank.

Great care should be taken when handling a liquid nitrogen tank and its contents. Close attention should be paid to the vacuum port. Liquid nitrogen should not be spilt on it or loss of vacuum may occur rendering the tank dysfunctional. Signs of vacuum loss include a strong hissing sound and ice crystal formation around the neck of the tank. It is important to monitor liquid nitrogen levels on a regular basis to make sure the levels are adequate in order to avoid semen damage. A liquid nitrogen tank measuring stick should be used for estimating the liquid nitrogen levels. It is important to take good care of the tank by routinely doing the following:

- Regularly replenish the liquid nitrogen in the tank to avoid levels falling low and damaging the semen. Liquid nitrogen is lost through evaporation, and each time the tank is opened. If the semen straw is not submerged in the liquid nitrogen its temperature will rise resulting in death of the spermatozoa.
- Canisters should not be raised more than 25cm above the neck of the tank, to prevent semen straws from being exposed to high temperatures as this may damage the spermatozoa. Once raised, the canister should be lowered back into the tank as soon as possible, preferably, within 3 seconds. This avoids excessive temperature fluctuation within the semen straws. When a canister is raised and then lowered into the tank, a bubbling/boiling sound is heard. This is due to the temperature change resulting from the relatively warmer canister heating up the liquid nitrogen.
- A semen inventory should be maintained to track semen straw quantities, use, replacement and their canister assignment. This allows quick and easy location of the desired semen straw when it is needed for insemination.
- The top of each cane should be marked, clearly identifying the cane's contents. If possible, avoid storing semen straws from more than one buck in a single cane.
- A catalog or map of the tank's contents should be maintained. Any change in inventory within the tank should be noted in the map.
- The stopper should never be forced into the tank. Doing so will damage the tank, reducing its longevity.
- Dents to the tank should be avoided. Dents reduce the total volume of the tank and hence the liquid nitrogen holding time. Such tanks will require more frequent replenishment with liquid nitrogen, increasing the maintenance costs of the tank. Tanks should not be set unprotected on gravel, dirt, or concrete. They should be stored unboxed, in a clean, dry, visible, secure area, on surfaces such as clean carpet, wood, cardboard, a rubber mat, to protect the bottom from dents and scratches.
- The tank should be kept clean and hygienic to avoid contaminating semen straws during AI and also the likelihood of spreading disease from one farm to the next.

Practical Activities:

The following activities are undertaken to enable the trainees learn how to best handle liquid nitrogen tanks:

- Examination and appreciation of liquid nitrogen tanks and the various components
- Handling of liquid nitrogen
- Handling and maintenance of liquid nitrogen tanks
- Semen packaging in straws and storage in liquid nitrogen tanks
- Labelling on semen straws
- Semen transfer from liquid nitrogen tanks
- Semen inventory

Artificial insemination

Artificial insemination is a technique whereby semen collected from the buck is deposited by an AI service provider in the right place in the reproductive tract of the doe at the appropriate time. Usually the semen used is processed. After collection and evaluation, the semen that meets the required standards is extended to increase its volume so that it can give many breeding doses. Semen extension involves use of semen diluents or extenders that will nourish the spermatozoa and provide a good environment for their survival. The volume of extender added to the semen is worked out in such a manner that the resulting doses obtained from each ejaculate will contain a sufficient number (i.e. at least 20 million spermatozoa in each straw at the time of freezing, with at least 8 million being alive post-thaw) to cause fertilization. After extension the semen is packed, commonly in straws, and can be used fresh within a few hours, chilled for use within a few days, or frozen in liquid nitrogen for use even after many years. The standard procedure for inseminating does involves raising the rear quarters of the doe, with the forequarters on the ground, and with the help of a speculum and light source, locating the right position and depositing semen into the female reproductive tract.

The advantages of using AI for breeding include:

- It increases the rate of genetic improvement through maximal use of genetically superior bucks.
- It increases the number of does to which a buck could be bred, as a single ejaculate can be extended into several breeding doses.
- It enables introduction of new genetics whose availability may be limited by geographical location. Processed semen is light and can be transported across a long distance.
- It reduces the risk of sexually transmitted diseases by eliminating natural mating.
- It eliminates the cost of keeping a buck and the nuisance of having a buck in a herd
- It is possible to accurately time when kiddings will occur since the breeding dates are known. This enables planning for presence of assistance during delivery if it will be needed.
- If accompanied by good record keeping, it allows for more accurate pedigree recording in a herd.

Disadvantages of AI:

- The AI equipment are expensive and liquid nitrogen is not available everywhere
- There will be increased labor costs for heat detection and insemination.
- There is potential for rapid spread of undesirable traits, if bucks from which semen is sourced are not carefully evaluated. Since a semen from a superior buck can be used to breed many does and even across borders. If the buck had a genetic defect this will be widely spread in the population.,
- If not well executed (i.e correctly timed, semen quality ascertained and qualified technician used), there is possibility of low pregnancy rates compared to natural mating.

The success of any AI program is largely dependent on three primary factors:

1. Use of viable semen. This is achieved by sourcing semen from reputable sources and proper handling and use of semen and the liquid nitrogen tank.

2. Appropriate timing of insemination relative to oestrus. If the doe is inseminated too early (before ovulation) or too late (after ovulation), the result will be low conception rates. It is important to try and establish at what stage of oestrus the doe is in prior to inseminating her. This can be done by establishing when the doe was first seen on heat by critically interviewing the farmer/herdsman, and also by examining the mucus in the anterior vagina using a speculum and light source. Clear, thin, mucus is indicative of a doe that is early in oestrus. Cloudy mucus indicates a doe towards the end of oestrus. White or pale yellow thick/cheesy mucus indicates a doe coming out of oestrus.

3. Proper deposition of semen in the doe's reproductive tract. During natural mating, semen is deposited inside the vagina next to or around the opening of the cervix. However, during AI, semen is deposited within the cervix or uterine body. Processed semen is diluted and a smaller volume is used. One of the reasons for low conception rates in goat AI is deposition of semen in the anterior vagina of the doe. Therefore, for good conception rates, the AI gun should be passed through the cervical opening (os cervix) for the semen to be deposited in the cervix or uterine body.

Not every doe presented for AI must be inseminated. Only does that are in good health (body condition score of 2.5 to 3 on a scale of 1 to 5), are on a rising plane of nutrition, free from diseases, and good mothers should be bred using AI. Does that do not have regular cycles or those which are difficult to determine when or if they are in oestrus should not be bred by AI, but rather by natural mating.

Artificial insemination equipment

The following equipment and facilities are required for proper AI execution:

- Breeding stand or facilities to restrain the doe.
- Carrying case. A compact metal or plastic case for the safe and clean storage of AI equipment.
- Artificial insemination (AI) gun. A goat length (usually 12 inch) device for delivering semen via a 0.25 or 0.5 ml straw. It can be disposable, or metallic for multiple use.
- AI gun sheaths. They are sterile disposable plastic tubes that are applied over the AI gun to anchor the semen straw.
- A light source which should fit in the vaginal speculum. It should generate little or no heat. A penlight could also be used.
- Vaginal speculum (Figure 8). It is used to open the reproductive tract and together with the light source enables clear visualization of the opening of the cervix.

Figure 8. Different sizes of a type of vaginal speculum, for use in different sized does.

- Liquid nitrogen tank (Figure 9). A large metallic vacuum flask for holding liquid nitrogen in which semen straws are kept for long term storage.

Figure 9. Liquid nitrogen tanks.

- Liquid nitrogen tank measuring stick. For accurate monitoring of the level of liquid nitrogen in the tank. Measure the liquid nitrogen at least weekly.

- Straw tweezers. For retrieval of semen straws from the liquid nitrogen tank, and also from the thawing bath.

- Straw cutter. It enables a square cutting of the tip of the straw so that it seats properly in the AI gun sheath for appropriate semen deposition. A pair of scissors can also be used.

- Lubricant. For lubrication of the vaginal speculum prior to its insertion into the vagina. It should be sterile and non-spermicidal.

- Semen thaw kit (Figure 10) or thermos flask with water thermometer, and a timer. It is for the proper thawing of semen at the right temperature.

Figure 10. Semen thawing kit: Should consist of a thermos flask with warm water, a thermometer and timer.

- Paper towels. For cleaning the vulva and drying the straws.

- Records. Can be in the form of a book, card, or electronic. Records are important for assessing the reproductive performance of the does.

Artificial insemination step by step and critical points:

1. Ensure the presented doe is actually on heat. This can be established by a thorough discussion with the farmer or animal handler on what has been observed to warrant the animal being said to be on heat.

2. Great care should be exercised to ensure that all the AI equipment is as clean as possible.

3. Restrain the doe. It can be placed in the breeding stand, on a milking stand, or a similar elevation. The hind quarters could also be held up by holding the rear legs up with flexed hocks (Figure 11) to allow ease of access to the reproductive tract. Wipe the perineum clean and dry it.

Figure 11. Doe restrained with rear parts raised.

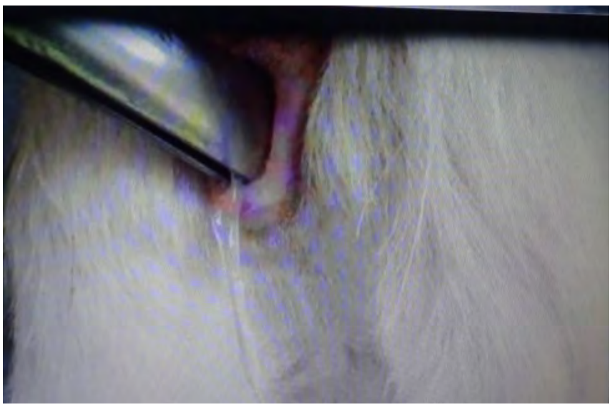
Figure 12. Insertion of speculum.

4. Apply lubricant on to the speculum and insert it into the reproductive tract of the doe to check the nature of mucus in the vagina. The lubricant should just be enough and not too much. Too much lubricant may interfere with sperm movement in the reproductive tract.

Figure 13. Lubricated speculum in reproductive tract of doe.

Vaginal mucus changes during heat. At the beginning of heat, very little mucus is present. As heat progresses, the mucus is transparent and found on the floor of the vagina. Towards the end of heat the mucus is cloudy: **this is the best time to inseminate**. The AI should be just before or when the mucus turns cloudy – usually 12 to 15 h after start of heat. If the doe is still on heat 12 h later, it should be bred again. At the end of heat the mucus is cheesy and white.

Figure 14. Oestrus mucus in the doe.



5. Identify the right canister (usually in different colours or numbers, denoting different bucks) with the cane with the required semen straw (Figure 15).

Figure 15. Liquid nitrogen tank showing different numbers and colors for different canisters.

6. Lift canister only enough to read the canes (Figure 16).

Figure 16. Raised canister showing semen straws.

7. Using tweezers or forceps pick up the required straw from the cane and quickly replace the cane (Figure 17).

Figure 17. Semen straw being picked from canister.

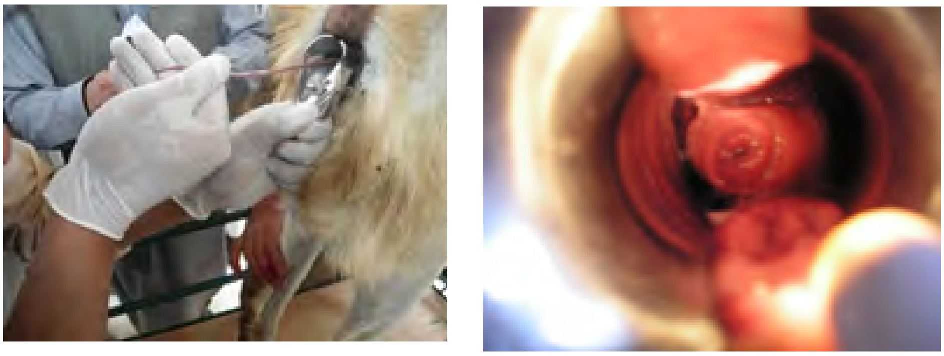
8. Immediately place the straw in the thawing bath. Make sure the temperature is right (35 to 40°C). Thaw the straw for 30 to 45 seconds. Rule of thumb: higher temperature shorter time and vice versa.

9. Remove straw from thaw bath, wipe it dry, and shake the air bubble to the end of the straw that will be cut.

10. Load the semen straw into a warmed, dry, clean AI gun. Pull the plunger back on the AI gun and place the straw into the gun with the cotton plug toward the plunger. After the straw has been secured in the gun, the sealed end of the straw should be cut at a right angle with a straw cutter or sharp scissors. Apply the sheath over the AI gun and secure it with the O ring.

11. Slowly and gently insert the lubricated speculum and light source into the reproductive tract by using a twisting motion and slight pressure to visualize the cervix. The speculum may have to be moved slightly back and forth or sideways to identify the cervix, which looks like a small rosette-shaped structure (Figure 18).

Figure 18. Picture showing light source and cervical opening of the doe.



Pictures courtesy of Joanna, EMBRAPA, Brazil

12. Press the speculum against the opening of the cervix (os cervix). With the aid of the light source, insert the loaded AI gun into the speculum and thread it into the cervix. Use circular motion and slight pressure to advance the AI gun through the rings of the cervix and place it as far as possible into the cervix (1 to 1.5 inches). Semen is best deposited deep into the cervix or uterine body. Where it is difficult to get through the cervix, such animals should be bred naturally.

13. Slowly deposit the semen by gently pushing the plunger of AI gun (Figure 19). If the plunger is pushed too rapidly some semen will remain in the AI gun.

Figure 19. Insertion of loaded AI gun through the speculum.

14. Remove speculum and AI gun. Discard the AI sheath. Clean the speculum in warm soapy water, rinse in distilled water or alcohol and air dry in a dust free environment (Figure 20).

Figure 20. Various AI equipment ready for cleaning.

Picture courtesy of Joanna, EMBRAPA, Brazil

15. Fill in the records. Record the breeding information, which should include, but not limited to: date, identity of the doe and the buck used. It is advisable to leave the used semen straw with the farmer, preferably attached to the AI record card.

Note: AI can also be done using fresh or chilled semen.

Practical Activities: Each trainee, under close supervision by a trainer, repeatedly goes through the following:

- Artificial insemination hands-on practice on does on heat until proficiency is attained
- Artificial insemination recording
- Assessing causes and management of AI failure.

Oestrus synchronization

Oestrus synchronization is the manipulation of the estrous cycle of does so that many can come on heat at the same predicted time, or a doe so that she comes on heat at a predictable time.

Advantages of oestrus synchronization include:

- It improves the accuracy of prediction of oestrus as heat is expected to occur within a specified time period.
- It makes heat detection easier as observation for heat signs can be concentrated at the specific period within which it is expected to occur, and not every day. This will cut down on the time and labor costs of frequent heat observation.
- It improves the efficiency and cost of AI as many synchronized does can be inseminated at the same time by the same inseminator. When an AI technician serves many does in the same area around the same time this will cut down on the cost of each insemination due to economics of scale. The AI will also be more efficient as determination of the stage of oestrus in inseminated does can be more easily established than in those that come on heat naturally.
- It can enable fixed-time AI. Oestrus synchronization, especially under intensive goat production systems, can utilize protocols that enable AI to be done at a specific predetermined time following a synchronization treatment irrespective of whether the does are seen on heat or not. This saves on time and cost of heat observation.
- It can allow for clustered kiddings thus enable more efficient herd management and market access:
  - Several young kids born around the same time can be more intensively taken care of for limited periods, as opposed to all year round when kiddings are not controlled.
  - Kidding can be synchronized to occur at specific times to coincide with market needs for example when there is feed availability for the dam and young for milk production and growth, or market demand for goats.

Different methods are available to synchronize oestrus in does. These include:

- Use of exogenous hormones
- The male/buck effect

Hormones for estrous synchronization

Two hormones, progesterone and prostaglandin F2α (PGF2α) are the primary hormones used for oestrus synchronization. However, other hormones such GnRH have been incorporated in various protocols.

Progesterone

It mimics the function of the corpus luteum by preventing hormonal activity that controls the estrous cycle. Progesterone blocks the secretion of FSH and LH from the pituitary gland and therefore follicles do not develop and grow on the ovary, consequently blocking the estrous cycle. It is administered for a number of days and then discontinued. Once discontinued, the block it had on FSH and LH secretion is removed. The decreased progesterone concentration results in the release of FSH and LH, follicular development and maturation in the ovary, and oestrus can be expected in 24 to 36 hours of removal. It can be administered as:

- Vaginal sponge. It is put in the anterior vagina of the doe.
- A Controlled Intravaginal Drug Release (CIDR) device. A CIDR is a plastic device that contains progesterone. These devices are usually used in conjunction with GnRH and PGF2α. The CIDR is inserted in the doe's vagina for 8 to 17 days following the injection of PGF2α. As long as the CIDR is in place it releases progesterone into the bloodstream of the doe. When the CIDR is removed, there is rapid fall in progesterone level, much as progesterone falls in the normal cycle, and the does come on heat within 72 hours.
- Implant. It is put below the skin in the ear or tail.

Prostaglandin F2α for oestrus synchronization

It causes regression of the CL, resulting in removal of the negative block progesterone has on FSH and LH release. When this progesterone block is removed, follicles develop, mature and the does come on heat within 36 to 72 hours of administration. It is given as an injection. It is cheaper than using progesterone. However, it only works when there is a responsive CL on the ovary, and this limits its use as there are periods within the estrous cycle when it will not be effective. Two doses of PGF2α 11 days apart will synchronize a group of does. Prostaglandin has to be used with care as it can cause abortion in pregnant does.

The male/buck effect for oestrus synchronization

The buck can be used to stimulate oestrus activity in does that have been previously isolated from bucks. After a period of separation, the buck is suddenly introduced into a group of sexually mature does. Many does may come into heat within 3 days of buck introduction.

Practical Activities:

The trainees are asked the following questions and are each requested to provide the answers, which are then further discussed:

- When do most kiddings occur in your area?
- Is goat breeding planned in your farms?
- If yes, for what purpose?
- What methods are used for controlling breeding?
- For those who perform AI how do you conduct the run?
- What factors determine the cost you charge the farmer for AI service?
- What challenges do you face in goat AI practice?
- What solutions would you suggest for the challenges identified above?

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