

Biology of Reproduction of Goats

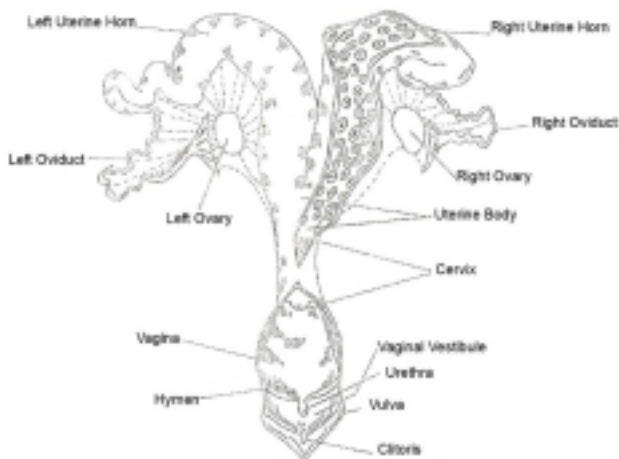
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Introduction

Reproduction is considered a primary trait of economical importance in animal production systems. Within this context, there is a need to adequately manage the reproduction of bucks and does to increase reproductive efficiency and herd production. Through reproductive management, goat herds may improve production levels. In order to understand and manipulate the reproductive processes of goats, it is important to be aware of their reproductive systems and functions.

Doe's Reproductive System

As seen in Figures 1 & 2, a doe's reproductive tract is composed of the following:

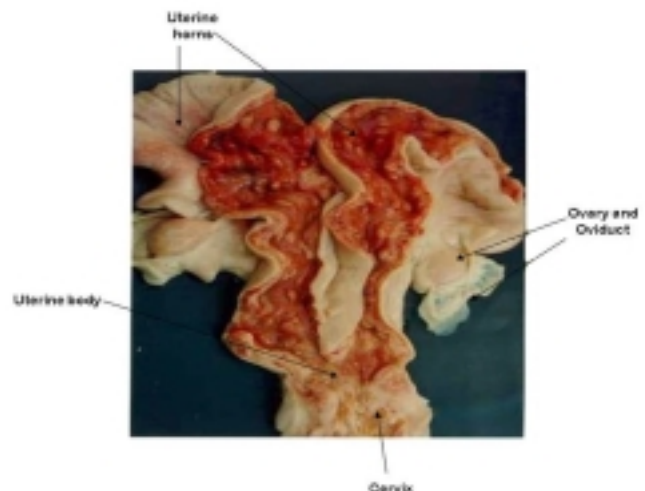


Ovaries

Ovaries are almond-shaped, paired, and located on each side of the pelvic cavity. They produce the ova or female gametes and sex steroid hormones such as estrogen and progesterone. Estrogens are responsible for the development of the secondary sex characteristics of does and the physical and behavioral changes that does display during heat. Progesterone is responsible for changes in the uterine environment for embryo implantation, as well as for maintaining pregnancy and promoting mammary gland growth and development during pregnancy.

Oviducts

Oviducts are tiny, convoluted tubes located on each side of the uterus that connects the ovary to the uterine horns. The oviducts are divided into three distinct segments that transport



Figures 1 & 2. Doe's Reproductive Tract

the ova and spermatozoids in opposite directions. Once the ova are released from the ovary during ovulation, they are captured in the oviduct. The oviduct is the site where the ova are fertilized. In a segment known as the *ampulla*. The oviduct is the site where further capacitation of the spermatozoa occur.

Uterus

A doe's uterus is bicornuate, which means that it has two long cornus or horns that connect the uterine body to the oviducts. Does are known to have a small uterus, generally 3 cm in length and 2 cm wide. The uterus is a smooth, muscular organ that stretches during the pregnancy along with the growth of a fetus or fetuses. The uterus protects and provides nourishment to the embryo and fetus during pregnancy. The uterus is also the site where the sperm cells reach maturation or capacitation, and where the embryo migrates and develops throughout the pregnancy until parturition.

The endometrium, or internal layer of the uterus, is formed by glands that secrete endometrial milk that nourishes the embryo. The endometrial glands also secrete prostaglandin $F2\alpha$ or $PGF2\alpha$, a hormone responsible for the luteolysis or degradation of the corpus luteum (CL) at the end of the estrous

cycle or days before parturition. The uterus separates itself from the vagina through a cartilaginous structure named the *cervix*.

Cervix

The cervix is a fibro-cartilaginous-like structure composed of three or four cartilage tissues named *rings*. The cervix connects the uterus with the vagina.

The cervix has an anterior and a posterior opening or OS. The cervix remains closed; however, it opens during heat under the influence of the hormone estrogen to facilitate the penetration of the sperm cells. The cervix is also opened during parturition for the passage of the fetus. During pregnancy, the cervix enlarges like the uterus. The inner layer of the cervix has secretory cells that produces a thick mucus, or "plug," that accumulates during pregnancy to protect the uterine environment against pathogens or infectious agents and foreign bodies.

Vagina

The vagina is a large and tubular elastic structure 9 to 15 cm in length. It is located between the cervix and vulva. The vagina is the copulation organ of the female, receiving the penis during mating, and it expands during birth.

Vulva

The vulva is the external genitalia consisting of the vestibule and the labia. The vestibule, generally 3 cm in length, is common to the urinary and genital tract. The vestibule joins the vagina with the urethral orifice.

The labia consists of the labia majora and minora, the outer and inner folds of skin outside the vagina. The labia

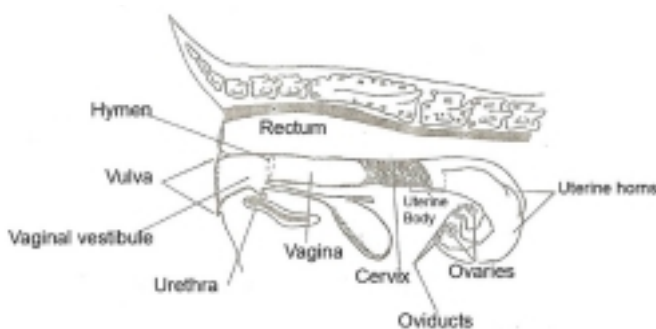


Figure 3. Doe's Reproductive Tract

Table 1*Doe's Reproductive Organs and Functions*

Organ	Functions
Ovaries	Produces the ova Produces estrogens (Graafian follicles) Produces progesterone (Corpus Luteum or CL)
Oviducts	Transports spermatozoa and ova, further site of spermataozoa capacitation Site of fertilization of the ova
Uterus	Site for spermatozoa capacitation Embryo and fetus retention and nourishment
Cervix	Transports spermatozoa Protects the uterus against foreign microorganisms
Vagina	Copulation and birth canal; site of sperm deposit during natural mating
Vulva	External genital
Clitoris	Excitatory organ of the doe

majora is homologous to the scrotum in males, and it is the visible external portion of the female tract.

Clitoris

The clitoris is located in the lower portion of the vulva. It is the excitatory organ of a doe's reproductive tract.

Supporting Structures

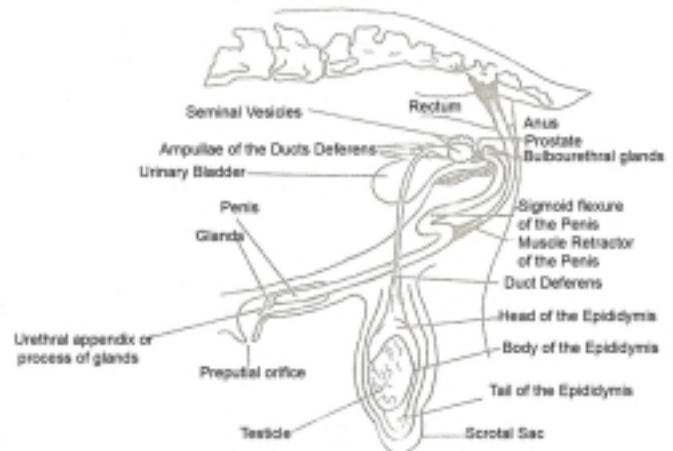
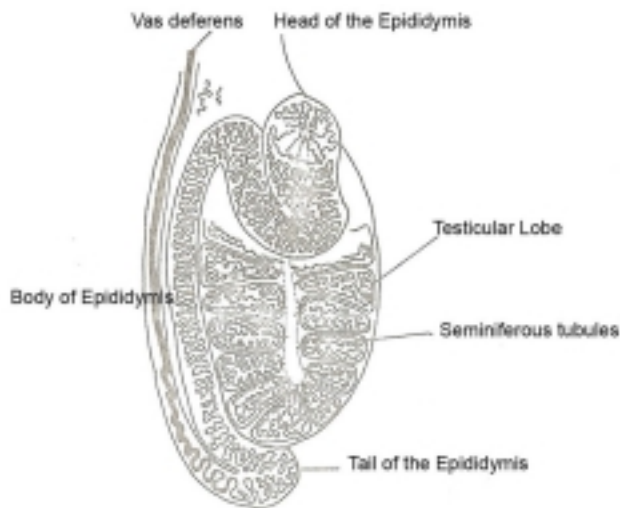
The female reproductive tract is located in the pelvic cavity, and is supported by the broad ligament. This ligament supports the ovaries, oviducts, and uterus. Blood vessels and nerves pass through the broad ligament to supply blood to the female tract.

Buck's Reproductive Tract

The buck's reproductive system (see Figures 4 and 5) consists of testes (testicles), scrotum, spermatic cords, accessory glands, penis prepuce, and the male duct system.

Testes

The testes or testicles are oval-shaped and paired. They are the main reproductive organs of a buck. The testicles are housed in the scrotum. They are symmetrical in shape and size, elastic to firm in consistency, and mobile in the scrotal sac. The primary functions of testicles are to produce spermatozoa or male germ cells in the seminiferous tubes, and to secrete steroid hormones (testosterone) by the Leydig cells. A buck within 8-14



Figures 4 & 5. Genital Tract of Male Goats

months of age should have 25 cm of scrotal circumference.

Scrotum

The scrotum is the sack-like pouch formed by the skin that is responsible for protecting the testicles and the epididymis that is located in the inguinal region between the legs. The scrotum also aids in the thermoregulation of the testicles.

Epididymis

This is the first external duct of the testicles that is divided into three parts: the head, body, and tail. The epididymis transports, matures, nourishes, and stores spermatozoa produced in the testes. It is the site where the spermatozoa acquire motility.

Spermatic Cord

The spermatic cord is composed of muscles and fiber tissues and a portion of the vas deferens. The cord connects the testicles to veins and arteries that irrigate the testicles in conjunction with the scrotum to position the testicles outside the body, and to help regulate the temperature of the testicles.

Vas Deferens

The vas deferens, or ductus deferens, are a pair of ducts tied to the tail or cauda of the epididymis. They pass along the spermatic cord to the pelvic cavity where they merge with the urethra. The vasa deferentia transport spermatozoa from the epididymis to the urethra.

Urethra

The urethra is a duct common to the urinary and reproductive tracts. A distal portion of the urethra is connected to the urinary bladder. The distal portion is inserted in the penis and serves in discharging urine and semen.

Accessory Glands

The accessory glands are located next to the urethra and consist of the vesicular, prostate, and bulbourethral glands. The accessory glands are responsible for producing seminal fluid that nourishes, serves as a buffer, and provides other substances needed for the motility and fertility of spermatozoa. The spermatic fluid and spermatozoa combined form the semen. Accessory gland fluids empty into the urethra.

Penis

This organ is responsible for male copulation and deposits semen in the female tract. The corpus spongiosum and cavernosum are expandable tissues that enlarge and fill with blood when arousal occurs. In this excitatory state, the penis is erect, facilitating copula and the ejaculation of semen in the female genital tract.

Prepuce

The prepuce is the sheath or foreskin that protects the penis.

Thermoregulation

The temperature inside a testicle is 2°C below body temperature. In cold

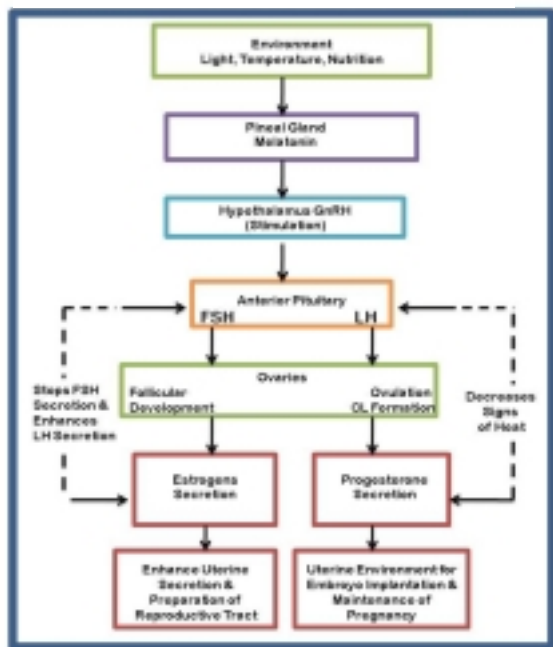
weather, the testicles rise near the abdominal cavity; in hot weather, the muscular relaxation permits testes to swing and hang down from the body. Structures responsible for thermoregulation are the muscles cremaster, dartos and the plexus pampiniform. This relaxed state maintains optimum temperature for the spermatogenesis to process and the spermatozoa to survive. A buck's low fertility rate is attributed to environmental conditions and the incapacity to regulate the optimum testicular temperature.

Table 2

Reproductive Organs and Functions of Male Goats

Organ	Major Functions
Testis or Testicles	Produce spermatozoa and testosterone
Scrotum	Support, protect, and regulate the temperature of the testicles
Spermatic Cord	Supports and regulates the temperature of the testicles
Epididymis	Concentration, nutrition, storage, maturation, and transport of the spermatozoa
Vas deferens	Transports spermatozoa
Urethra	Transports spermatozoa and urine, and forms semen
Accessory Glands	Production of seminal fluids to provide energy, buffer, and nourishment of the spermatozoa
Penis	Copulation organ
Prepuce	Encloses free end of penis for penetration

Table 3. Effects of Seasonality on Reproduction of DOES (Modification of FAO, 1987)



Hormonal Control of Reproductive Process and Doe Cyclicity

The reproductive process is complex and regulated by hormones. Hormones are chemicals produced by endocrine glands and secreted and released in the bloodstream that act directly on target organs, or indirectly through the regulation of other hormones. These hormones can be classified as peptides and proteins or steroid hormones.

In temperate regions such as in the United States and Canada, goat breeds are seasonal or "short-day breeders." This means that the period of cyclicity is regulated by the photoperiod. Thus, the decrease in day length triggers neuro-endocrine and ovarian interaction that occurs during late summer and continues on through the fall and winter months. Seasonality can be a limiting factor in the reproductive

process because it reduces the annual breeding season and limits the opportunity for producers to market their kids year-round.

The phenomenon of photoperiod is regulated by melatonin, a hormone produced by the pineal gland. The pineal is an endocrine gland located in the brain. The reduction in daylight exposure stimulates the optic nerve of the retina, which, in response, stimulates the cells of the pineal gland to secrete melatonin. Higher levels of melatonin trigger a sequence of positive and negative feedback involving several endocrine glands and the gonads.

The increased levels of the gonadotropin-releasing hormone (GnRH) generated from the hypothalamus, a gland located in the brain, triggers doe cyclicity. The GnRH stimulates the cells of the anterior pituitary, or hypophysis, located at the base of the brain to secrete the follicle stimulating hormones (FSH) and the luteinizing hormone (LH). The FSH supports the development and growth of primordial follicles into secondary and tertiary follicles. These follicles produce estrogens. The increase in hormone estrogens will induce the production of LH surges, triggering ovulation or the release of the ova from the graffian follicles. After ovulation, the ova are captured in the oviduct, where in the presence of spermatozoa, they will be fertilized to generate an embryo.

After ovulation, the cells of the ruptured follicle will be transformed by luteinization to form a new ovarian structure called the *corpus luteum* (CL). The luteinization process is promoted by the action of LH. During

the fifth day of formation, the CL is active, secreting progesterone to maintain a possible pregnancy. The maintenance of the CL is determined by the presence of an embryo. In case of pregnancy, the CL remains active, secreting progesterone to maintain the appropriate uterine environment for fetal development during pregnancy. In the case of a nonpregnancy, the CL will suffer luteolysis or regression.

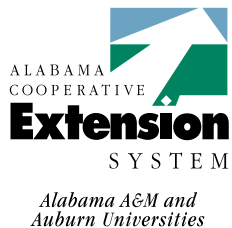
Luteolysis is caused by the action of prostaglandins F_{2α} secreted by uterine glands. The prostaglandin PGF_{2α} is transported from the uterus to the ovaries through the arteries and uterine vein connections to promote luteolysis or regression of the CL. The regressed CL will allow the ovary and other endocrine glands to prepare for another cycle.

In bucks, the main class of androgens is the testosterone that is produced in the testicles by Leydig cells. Testosterone is responsible for a buck's secondary sex characteristics, to maintain the libido, and to promote the function of the accessory glands and spermatogenesis among others. Testosterone regulates the release of hypothalamic and anterior pituitary hormones like progesterone in does.

The process of spermatogenesis in a buck takes 49 to 63 days, while spermatozoa are formed daily during the life of a buck. However, the daily sperm production and quality of ejaculation decrease according to day length.

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