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21

Diseases of the Testes

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Abstract

Diseases of the testes are conditions of abnormal function or structure of the testes. The reproductive functions of the male involve the formation of sperm and the deposition of the sperm into the female. Diseases of the testicles will affect the reproductive function of the organ and could include testicular and epididymal abnormalities, varicoceles, orchitis, epididymitis, besnoitiosis, testicular hypoplasia, persistent müllerian duct syndrome, cryptorchidism, trypanosomosis, intersex, testicular atrophy and degeneration, sperm granulomas, etc. These could impair the spermatogenetic and steroidogenic function of the testicles leading to infertility.

Keywords: diseases; goat; bucks; testes; spermatogenic; steroidogenic

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21.1 Introduction

The male goat is called a buck or billy. Many dairy goat owners are offended by the term “billy,” and Angora breeders are often confused by “buck” because in many parts of the United States, the ram (male sheep) is referred to as a buck. The buck is frequently described as half of the breeding herd. Many owners find him the more difficult half to control. Because of his size and strength and his distinctive odor, the buck is often skipped when the does are dewormed, vaccinated, given selenium injections, or foot trimmed (Kilgour 2019).

The reproductive functions of the male involve the formation of sperm and the deposition of the sperm into the female. Sperm are produced in the seminiferous tubules of the testes and are then transported through the rete testes to the epididymides, where they are stored and matured. The two testes produce spermatozoa (Walker and Cooke 2023). Although they vary somewhat in size, shape, and location among species, they share a similar structure.

The testicles are suspended away from the body by the pendulous scrotum. The scrotum is composed of undulating epidermis that may or may not be covered by wool, depending on the breed and husbandry practices. A rich plexus of blood vessels, lymphatics, and sweat glands lies beneath the skin. The dartos, a smooth muscle layer, is connected to the vaginal tunics of the testicle by the scrotal fascia (Koziol and Palmer 2023). The scrotal fascia is the connective tissue that is typically broken down when the clinician separates the skin from the testicle during routine castration. The vaginal tunics are outcroppings of the peritoneum and form a protective covering over the testicles. The space between the two layers of vaginal tunic (parietal and visceral) as it reflects around the testicle normally contains a small amount of peritoneal fluid (Koziol and Palmer 2023). The scrotal septum, composed primarily of the dartos muscle, divides the scrotum into two halves.

The seminiferous tubules are convoluted and occupy the greatest portion of each testicle. The spermatozoa are produced within them. The testicle is surrounded by a connective tissue capsule called the tunica albuginea. Support of the seminiferous tubules is provided by connective tissue extensions (septa or trabeculae) into the testis from the tunica albuginea. A cross-section of the testicle shows the relationship of the seminiferous tubules to each other and to their connective tissue support (interstitial tissue).

In addition to spermatozoa in various stages of development, two other important cell types are the Sertoli cell (sustentacular cell) and the Leydig cell (interstitial cell) (Lee et al. 2008). The Sertoli cell provides a "nurse" function for developing spermatozoa. Processes from Sertoli cells surround spermatids and spermatocytes and provide intimate contact with all stages of spermatozoa production; in this respect they are known as sustentacular (supporting) cells. The Sertoli cells have their base at the periphery of the seminiferous tubules and extend toward the center. The basal junction (tight junction) with adjacent Sertoli cells forms a blood–testis barrier that permits control of the environment within the tubule and also prevents spermatozoa from entering the interstitium.

The Sertoli cells divide the seminiferous tubules into two compartments: (i) the basal compartment, which communicates with interstitial fluid and provides space for germinal epithelial cells, and (ii) the adluminal compartment, which is the space between Sertoli cells that communicates centrally with the lumen of the tubule. Division of a germinal epithelial cell (spermatogonium) in the basal compartment provides a replacement cell and another cell, which must move through the Sertoli cell junction to enter the adluminal compartment. Here, further divisions occur and spermatozoa are finally formed (Mruk and Cheng 2015). The Sertoli cells secrete a fluid into the adluminal compartment; its composition favors the developing spermatozoa. The seminiferous tubules drain into the rete testes, which in turn are drained by 10–12 efferent ducts. These ducts drain into the head of the epididymis, which is located on the dorsal craniolateral aspect of the testicle. The body of the epididymis curves around the lateral portion of the testes and ends caudomedially as the tail. The tubular structure is reflected dorsally and becomes the vas deferens.

Rams and bucks have a full complement of accessory sex glands. The small bulbourethral glands are located caudally in the pelvic cavity on either side of the pelvic urethra; they can be palpated rectally. They also have lobulated vesicular glands, disseminate prostate gland, and a widening of the vas deferens known as the ampulla.

Spermatogenesis requires about 49–60 days from the start of germ cell division until the sperm are released from the seminiferous tubules. Another 10 days to two weeks are required for the sperm to pass from the seminiferous tubules through the epididymis (Lee et al. 2008).

21.2 Epididymis

The epididymis is a collection and storage tubule for the testis (Figure 21.1). It begins at the pole of the testis in which blood vessels and nerves enter; this is known as the head of the epididymis. The head continues along one side of the testis as the body of the epididymis, which terminates before making a turn upward as the tail of the epididymis. The head of the epididymis receives sperm and adluminal fluid through efferent ducts from the rete testis (the intratesticular network of straight tubules that receives content from the convoluted seminiferous tubules). Spermatozoa move to the epididymis by the flow of fluid into the lumen of the seminiferous tubules from the adluminal spaces (Figure 21.1) (Fietz and Bergmann 2017). Storage in the epididymis allows the spermatozoa to reach maturity and become motile. Reabsorption of much of the seminiferous tubular fluid occurs in the head of the epididymis.

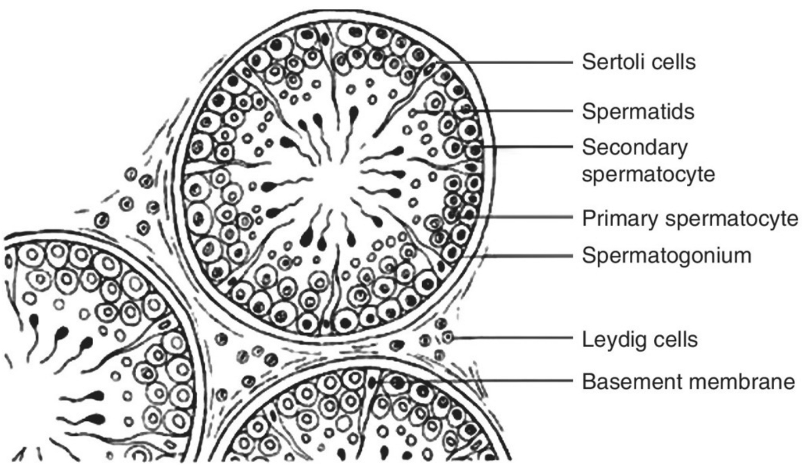

Figure 21.1 Relationship of the seminiferous tubules to each other and to the interstitial tissue.

21.3 Ductus Deferens

The ductus deferens, sometimes called the vas deferens, is the continuation of the duct system from the tail of the epididymis to the pelvic urethra. As the ductus deferens leaves the testis, toward the abdomen, it is enclosed along with the testicular artery, vein, and nerve, and lymphatic vessels within the visceral layer of the vaginal tunic. This combination of structures is known as the spermatic cord. The visceral layer of the vaginal tunic also envelops the testis and epididymis. It is derived from abdominal peritoneum of embryonic origin when the testes descended to the scrotum via the inguinal canal.

The inguinal canal is an oblique passage from the abdominal cavity to the exterior of the body that extends from the deep (interior) inguinal ring to the superficial (exterior) inguinal ring. The inguinal rings are slits in the tendinous attachments of the two flat abdominal muscles to the pelvis. After the spermatic cord passes through the inguinal rings, the ductus deferens separates from the spermatic cord to proceed to the pelvic urethra. The ductus deferens terminates with an enlarged, glandular area (variable size among species), known as the ampulla of the ductus deferens (absent in the boar) (Hamada and Saadeldin 2022).

The interstitial tissue is occupied not only by the usual blood vascular network but also by Leydig cells (interstitial cells) and by connective tissue septa (provide support for seminiferous tubules) from the connective tissue capsule (tunica albuginea) of the testis. The rete testis is a network of straight tubules connecting convoluted seminiferous tubules with the highly convoluted epididymal tubule via efferent ducts (extratesticular). The flow of spermatozoa with their fluids is shown by the arrows in Figure 21.2 (Pathak et al. 2022).

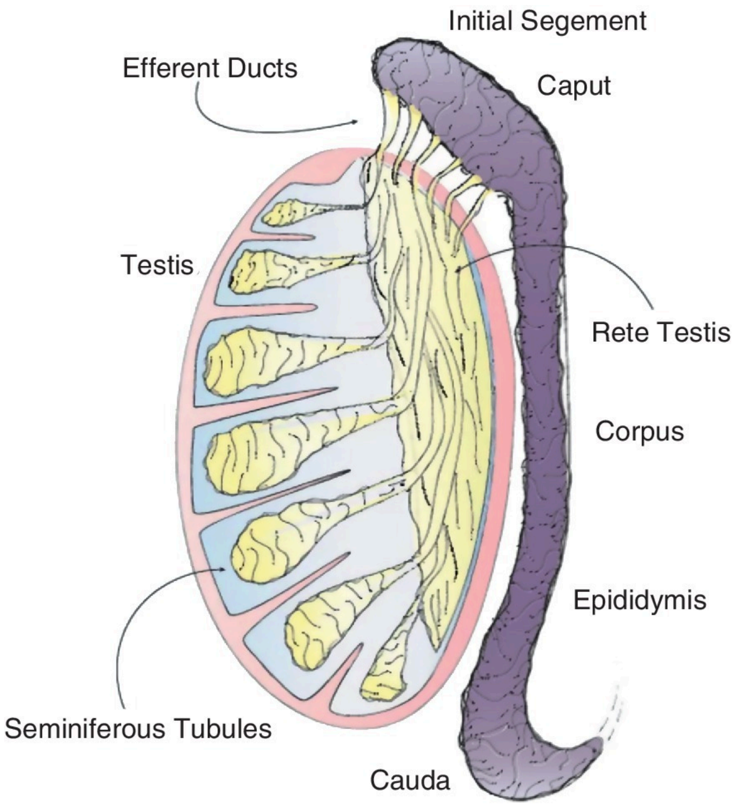

Figure 21.2 Testes showing seminiferous tubules and excurrent ducts.

21.4 Effect of Season on Buck Puberty and Reproduction

Breed, age, and nutrition contribute to the onset of sexual maturity in the buck. The age at puberty depends on the breed, varying from 2–3 months in pygmy breeds to 4–5 months in Nubian and Boer bucks (Rouatbi et al. 2022). Most breeds of goats raised in the temperate environment of the northern hemisphere have sperm in the ejaculate at 4–5 months. However, at this age their semen quality is poor and they are not suitable for breeding.

Nubian and Boer bucks begin exhibiting libido at 10–12 weeks and start producing quality semen at about eight months. Natural adhesions of the urethral process and glans penis to the prepuce make the immature buck incapable of copulation. This attachment begins to separate at three months, and fertile mating is possible at 4–5 months. Fast-growing, well-fed, and well-managed kids are able to breed sooner than starved males of equal age.

Whether bucks are truly seasonal breeders is controversial. Many bucks have depressed libido, reduced pheromones, decreased scrotal circumference (SC), lower semen freezability, and a larger number of abnormal spermatozoa outside the breeding season (Rouatbi et al. 2022). All these changes reflect lower levels of LH and testosterone. LH and testosterone concentration, libido, and odor presence in the buck peak in the fall. Sexual behavior of the buck includes actively seeking does in estrus, courtship (kicking, pawing, muzzling, grunting, and flehmen), mounting, intromission, and ejaculation. Ejaculation occurs spontaneously and is characterized by a strong pelvic thrust with a rapid backward movement of the head. After ejaculation the buck dismounts and shows no sexual arousal for a few minutes to several hours (Shipley 2022).

21.5 Diseases of the Testes

Except for changes induced by fever or malnutrition, most abnormalities are not amenable to treatment.

21.5.1 Procedures for Evaluating Testis and Epididymis

In addition to judging the testicular volume by scrotal circumference or the diameter of each testis by the use of calipers, the consistency of the testes should be evaluated. Normal testicular tissue should feel resilient and approximately as firm as muscle. Its ultrasonographic appearance is uniformly homogeneous with a central hyperechoic line representing the mediastinum testis. The testicular tunics and testicular capsule are also distinct hyperechoic lines, whereas fluid around the testis (hydrocele) is hypoechoic. The tail of the epididymis is more heterogeneous and less echogenic than the testis. The use of ultrasonography for evaluating testicular lesions has also been described for bulls.

Testicular biopsy is not routinely used in goats. In bulls, biopsy procedures have led to decreased semen quality. It is important to avoid highly vascular areas and to suture the incision in the tunica albuginea, or else hemorrhage and infarction may occur.

21.5.2 Varicoceles

A varicocele is defined as a localized dilation and thrombosis of the internal spermatic vein and is recognized as a fluctuant to hard swelling in the spermatic cord. Varicoceles are more common in rams than in bucks. This condition is often manifested as rear limb lameness and awkward posture as the ram tries to relieve pressure on the swollen cords. Affected animals may become weak and susceptible to other diseases as a result of debilitation brought on by an unwillingness to walk to obtain food and water.

Varicoceles can be diagnosed by palpation and diagnostic ultrasound. Abnormalities such as decreased total sperm count, reduced sperm motility, and morphological abnormalities of the sperm are often associated with varicoceles. The exact etiology of the condition is not known but a genetic predisposition is suspected. No easy treatment is available, and affected rams or bucks should be culled (Foster 2016).

21.5.3 Epididymitis

21.5.3.1 Epididymitis in Older Males

Epididymitis is a rare condition in the buck but a clinically important disease in rams. Epididymitis in rams should be considered to be caused by *B. ovis* until proven otherwise. This is especially true of older rams that have been actively breeding in multiple sire units. However, one case report involving an outbreak of *B. ovis* in a group of virgin ram lambs suggests that the disease may be spread *in utero* or neonatally, before any known sexual activity. The primary means of spread is thought to be through contact with mucous membranes, which results in bacteremia. The organism localizes in the epididymis and secondary sex glands. Contact can occur among rams and from recently infected ewes; venereal and oral–nasal transmission routes also are possible.

Swelling of the epididymis is the primary presenting sign, occurring about three weeks after the initial exposure. Grossly, there is localized inflammation followed by hyperplasia and obstruction of the epididymal ducts. This obstruction causes a back-up of spermatozoa, the development of sperm granulomas, and pressure necrosis. The seminal vesicles also are commonly affected, which may account for the large number of infected rams that show no palpable signs of epididymitis. Semen collected from infected rams usually contains a large number of polymorphonuclear neutrophils that can be seen on the motility preparations or on Wright's stained specimens. Serology for *B. ovis* should be considered a routine part of a breeding soundness examination. Both enzyme-linked immunosorbent assay (ELISA) and complement fixation (CF) tests are available.

Herd infections with *B. ovis* can result in a 15–30% reduction in lambing rate depending on the chronicity of the herd problem. This decrease in reproductive efficiency results from lowered fertility in the rams, failure of the ewes to conceive, reabsorption of embryos, abortions, stillbirths, and weak lambs. Recommendations outlined by Bulgin (1990) include the following.

- Buying virgin rams that have been serologically tested for brucellosis.
- Keeping newly purchased rams separate until all rams are tested free from *Brucella*.
- Performing palpation and culling all rams with epididymitis before the breeding season.
- Culling all *B. ovis*-positive rams.
- Retesting all rams in the flock 60 days after any rams are found positive.
- Performing BSEs yearly on all rams. If a large number of serologically positive rams is found after a year of adherence to these guidelines, efforts should be made to determine whether a serologically negative carrier ram is present in the flock by culturing semen from all rams (Sathe and Shipley 2014).

21.5.3.2 Epididymitis in Young Males

In younger rams, and less commonly in bucks, epididymitis can be caused by a number of organisms such as *Histophilus*, A*ctinobacillus*, and *Haemophilus* species, as well as *Corynebacterium pseudotuberculosis*. Lamb epididymitis can be spread from ram to ram by the oral or nasal route. The organisms responsible for lamb epididymitis can frequently be cultured from the preputial cavity of rams younger than two years of age and are commonly found in the mucous membranes of the prepuce, penis, mouth, and nasal cavity. Colonization and subsequent disease of the reproductive tract may depend on the hormonal changes that occur during maturation and puberty, along with other unknown differentiating factors that allow most animals to eliminate the bacteria spontaneously while causing others to develop clinical signs.

Diagnosis of lamb epididymitis is made by palpation of the enlarged epididymis and by ruling out *B. ovis* infection. Semen from infected lambs is characterized by a large number of neutrophils and by the morphologically abnormal spermatozoa typical of epididymal disease. Although the signs of most cases of lamb epididymitis are restricted to the reproductive tract, occasionally an associated fever and hindlimb lameness also occur.

Lamb epididymitis can be treated with long-acting oxytetracycline (20 mg/kg intramuscularly or subcutaneously) injections for three treatments at three-day intervals. Inclusion of tetracycline (20 mg/kg by mouth daily) products in the ration may be appropriate in herds experiencing a high incidence of lamb epididymitis. Treatment should be reserved for valuable lambs and cases diagnosed in the early stages because most lambs develop scar tissue in the epididymis that prevents functional recovery (Stapelberg 2022).

21.5.4 Orchitis

Orchitis is a common occurrence in the ram and is occasionally seen in the buck. Scrotal abscesses may be caused by trauma or may be an extension of epididymitis. Whenever testicular trauma or infection is encountered, it should be considered a medical emergency in breeding animals (Crilly et al. 2022). Excessive heat from one testicle can result in possibly irreversible thermal injury to the germinal epithelium of the contralateral testicle. All the organisms discussed in the section on epididymitis can cause orchitis.

The signs include a hot, swollen scrotum (usually unilaterally), inability to move the affected testicle freely in the scrotum, and pain on manipulation of the affected testicle and the scrotum. Some animals may show signs of systemic disease, pain on walking, and decrease in libido. In cases affecting valuable animals, hemicastration in the acute phase may prevent permanent infertility (Stapelberg 2022).

21.5.5 Sperm Granulomas

Although testicular tumors are rare in rams and bucks, granulomatous swellings are occasionally encountered. Sperm granulomas are more common in goats than in sheep, and unlike abscesses or other forms of orchitis, they usually occur bilaterally. Sperm granulomas are often caused by a partial or complete blockage of the efferent ducts draining into the epididymis. As pressure builds, the ducts become distended and may rupture, resulting in a severe inflammation. As fluid accumulates, pressure continues to build and testicular degeneration may occur. Some animals are initially fertile but lose fertility after the efferent ducts become completely occluded. Granulomas are firm swellings found in the head of the epididymis. On palpation, the testicles may be initially edematous but they eventually become hard. The testicles may eventually become small and atrophic. Ultrasonographic evaluation may reveal mineralization of the testicles or the granuloma itself.

No treatment is available for sperm granulomas, and the clinician should be aware of the potential association with the intersex condition (Crilly et al. 2022).

21.5.6 Testicular Atrophy and Degeneration

Testicular hypoplasia and degeneration are difficult to differentiate on initial examination. A common cause of testicular degeneration is debility from malnutrition or parasitism. The chronically recumbent buck might also experience testicular atrophy because of impaired thermoregulation in the scrotum. Sperm granulomas cause progressive testicular degeneration. In rams and bucks out of season, testicular size and palpation characteristics may be difficult to differentiate from subtle cases of testicular atrophy. More extreme differences are encountered in rams than in goats, but in general the testicle in the nonbreeding season is smaller and lacks normal resiliency.

Causes of testicular atrophy include zinc deficiency, hypothyroidism (iodine deficiency, ingestion of goitrogenous plants), starvation diets, systemic disease, and heat and cold stress. Iodine-induced hypothyroidism has been associated with decreased testicular weight, depressed spermatogenesis, and decreased libido. Atrophic or degenerated testicles become elongated, small, and either softer or harder. Normal testicles usually have a homogeneous echogenicity on ultrasound. Atrophic or degenerative testicles tend to have a heterogeneous pattern and more hyperechoic areas. Testicular biopsy can be of value in diagnosis.

Many cases of atrophy and degeneration are not treatable; the exceptions are cases caused by diet or certain diseases. In treating diet-related atrophy, ensuring adequate protein-energy intake and free access to a good-quality trace mineral supplement is essential. If zinc deficiency is suspected, reducing the legume content of the diet and adding a chelated form of zinc (zinc methionine) to the diet or trace mineral mixture is useful. If iodine-induced hypothyroidism is diagnosed, the inclusion of iodine in a trace mineral mixture and the removal of goitrogenous plants from the diet should be undertaken; males should be kept off pastures with goitrogenous plants before and during breeding (Crilly et al. 2022).

Multiple foci of calcinosis are grossly visible on cut surfaces of the testis. Histologically, granuloma formation occurs where masses of dead sperm have accumulated in collecting ducts (Fraser and Wilson 1966). Foci of testicular necrosis or mineralization are hyperechoic during ultrasonographic examination but only the echogenicity of the near-field testis should be assessed, because of attenuation of the far-field ultrasound beam. Firm, mineralized parenchyma, detectable by ultrasound, has been observed in elderly or infertile bucks. These changes are irreversible. Testicular neoplasia, although rare in goats, should also be detectable by ultrasonography. Atrophy and degeneration of the seminiferous tubules have been reported in goats in the Sudan experimentally fed *Acanthospermum hispidum*, which also causes hepatic necrosis and fibrosis. Likewise, the feeding of *Leucaena leucocephala* is reported to cause mild degeneration of the testes, possibly secondary to hypothyroidism.

Experimental hypothyroidism in goats (achieved by feeding thiouracil) was associated with a relative decrease in the weight of the testis and epididymis, a reduction in spermatogenesis, and degenerative changes in the testis and accessory sex glands. There was loss of libido, decreased ejaculate volume, decreased sperm concentration, motility, and viability, and an increase in abnormal spermatozoa. These changes were reversible. Thyroidectomy in young male goats also results in smaller than normal testes. Detrimental effects of naturally occurring hypothyroidism on testicular function in adult goats have not been documented.

21.5.7 Intersex

Caprine intersexes are referred to as *male pseudohermaphrodites* because a majority of them have testes. True hermaphrodites have testicular and ovarian structures and generally constitute a much smaller proportion of intersexes. Intersex is more prevalent in polled dairy goats (Saanen, Toggenburg, Alpine, and Damascus breeds). The polled intersex condition is rare or not reported in some breeds (Nubian and Angora). Cytogenetic evaluations of caprine intersexes clearly show that most polled intersexes are karyotypically female (XX), and the breeding histories of the parents indicate that intersexes are homozygous for the polled trait.

Affected animals are genetically female but may exhibit male, female, or mixed external characteristics. Generally, they are female-appearing at birth but as they reach sexual maturity, they become larger than normal females, with masculine heads and erect hair on their necks. An enlarged clitoris in a doe-like animal or a decreased anogenital distance in a more masculine individual is typical of intersex. Intersexes may start to smell and may act aggressively toward other goats and people during the breeding season. Some dribble urine or stretch out with a concave back and urinate forward between the legs.

Whenever bilateral cryptorchidism is encountered, intersex should be suspected. The testes are generally intraabdominal (in the normal location of the ovaries) but they may be partially or totally descended. Partially descended testes may be mistaken for udders, especially when they begin to enlarge during puberty. Hypospadias (opening of the urethral orifice on the ventral aspect of the penis), sperm granulomas, and hypoplastic testicles should all be considered part of the intersex complex. The principal hormone produced by the gonads in caprine intersexes is testosterone, which accounts for masculine behavior. Intersex goats can be used as teaser animals because they do not produce sperm. Gonadectomy is generally required if the animal is to be used as a pet.

Identifying intersex animals with normal or nearly normal external genitalia is difficult. Failure to exhibit estrus, development of male behavior during the breeding season, a shortened vagina on speculum examination, and smaller than normal teats may be the first signs of the intersex condition. The breeding of phenotypically polled bucks should be avoided.

21.5.8 Testicular Hypoplasia

Abnormally small testes most commonly occur with severe malnutrition (Neathery et al. 1973) or in animals that are actually intersexes (i.e., polled intersexes or freemartins). Hypoplasia is often difficult to distinguish from atrophy, but with either condition, testicular size and function should improve with proper feeding if malnutrition is responsible. Intersexes and freemartins do not produce any sperm at all, even in the breeding season, and generally are less odoriferous than normal bucks. Their testes do not undergo the increase in size that normally occurs at puberty, or else the testes may atrophy at that time (Crilly et al. 2022).

One case of testicular hypoplasia has been reported in a horned buck with chromosomal mosaicism (XXY and XY). Two sterile polled bucks with a Robertsonian translocation were found to have normal seminiferous tubules interspersed with tubules devoid of germinal cells (Ricordeau 1972). Histologically, similar findings have been reported in polled bucks with sperm granulomas obstructing the epididymis but with normal karyotype (Corteel et al. 1969).

Bucks with severe experimental zinc deficiency compounded by reduced feed intake and control bucks with just reduced feed intake in the same trial showed normal tubules adjacent to tubules containing only spermatogonia secondary zinc deficiency, caused by excessive fertilization of fields, resulted in atrophy of the seminiferous tubules, hyperplasia of the germinal epithelium, and thickening of the walls of blood vessels in the testes of young Black Bengal bucks (Ray et al. 1997).

Unilateral testicular hypoplasia (in males producing sperm) has been reported in two goats in India (Mathew and Raja 1978b) and in a polled Saanen XY buck in the United States (Sponenberg et al. 1983). In the Indian bucks, spermatogenesis only progressed to the formation of spermatocytes, while in the latter case, some seminiferous tubules in the affected testis were devoid of sperm cells while others were normal. Three additional bucks (horned feral animals) in Australia with unilateral hypoplasia had small seminiferous tubules lined by Sertoli cells (Tarigan et al. 1990). A unilateral segmental tubular hypoplasia in a testis of normal size but with discrete pale areas on section was been observed in two animals in this Australian slaughterhouse survey of 1000 bucks.

21.5.9 Cryptorchidism

Intersex animals, as discussed previously, may exhibit retained testes or ovotestes. The gonad may be abdominal or inguinal in location. The animals are usually genetic females or freemartins. No sperm are produced. Failure of one testis to descend into the scrotum has been reported frequently in Angora goats. Bilateral cryptorchidism appears to be rare in this breed. The cryptorchid goat is sometimes referred to as a “ridgling.”

21.5.9.1 Etiology

Cryptorchidism is hereditary in Angora goats but is not related to the polled intersex condition, which does not occur in this breed. Affected Angoras are genetic males (Skinner et al. 1972). The cryptorchid trait is recessive but controlled by a few pairs of genes (Warwick et al. 1961<<Query: AU: Please cross check and verify the updated citation here “Warwick et al. 1961” Ans: Replace with
Ruan, L., Gu, M., Geng, H., Duan, Z., Yu, H., Shao, Z., ... & Tang, D. (2024). Achieving an optimal pregnancy outcome through the combined utilization of micro-TESE and ICSI in cryptorchidism associated with a non-canonical splicing variant in RXFP2. Journal of Assisted Reproduction and Genetics, 1-11.>>). In other breeds, cryptorchidism in XY males occurs occasionally, and although less is known about the etiology, a genetic explanation is probable.

21.5.9.2 Clinical Signs and Surgical or Necropsy Findings

The testes normally descend into the scrotum by 12–13 weeks of gestation. Cryptorchidism is detectable at birth. If the condition is bilateral, no scrotum is present. In Texas Angoras and in Indian goats of unspecified breed (Mathew and Raja 1978a), the right testis was retained, whereas in South African Angoras, the left testis was retained (Skinner et al. 1972). In one research farm in India, six out of 89 Tellicherry bucks born during a four-year period were unilaterally cryptorchid. In five of these, the right testis was retained. In a slaughterhouse study in Ethiopia, 22 of 404 (5.5%) horned native breed bucks were cryptorchid; 18 of these were unilateral and 10 involved the right testis (Regassa et al. 2003). The unilaterally affected buck is generally fertile, although semen volume and sperm concentration are reduced. Mohair quality in cryptorchid Angoras is normal.

In the unilateral cryptorchid, the retained testis is often located near the kidney. In two Anglo-Nubian bucks in Brazil with unilateral cryptorchidism, the retained testis (one left, one right) was located at the entrance to the inguinal canal. If castration is required, as for a pet animal, the location of the testis can be confirmed before surgery by ultrasound. The tunica albuginea of the retained testis is echogenic and clearly demarcates it from surrounding tissue (Kaulfuss et al. 2006). This testis is generally smaller than the scrotal testis. The cryptorchid testis resembles a prepuberal testis histologically.

Sertoli cell degeneration has been described in the cryptorchid testis in West African dwarf goats (Ezeasor and Singh 1987), whereas tubular degeneration and Sertoli cell hyperplasia have been reported in two cryptorchid feral goats in Australia (Tarigan et al. 1990).

21.5.9.3 Prevention

The prevalence of the condition in a flock varies with the selection pressure against it, often approximately 2% but as much as 10% in commercial herds and more than 60% when cryptorchids are intentionally bred. Breeders wishing to sell bucks realize that a unilateral cryptorchid is of little commercial value. To decrease the prevalence of the condition, cryptorchid bucks should not be used for breeding and their sires and dams should also be culled. Even stricter selection involves culling all offspring of known carriers (Warwick et al. 1961).

21.5.10 Persistent Müllerian Duct Syndrome

A single male (60, XY) Nubian goat with bilateral cryptorchidism and persistent müllerian duct syndrome has been described (Haibel and Rojko 1990). Hypoplastic testes, rudimentary epididymides, and a bicornuate uterus were present. Vesicular glands, bulbourethral glands, and penis resembled those of a normal male. Similar syndromes are seen in miniature schnauzer dogs and human males and are thought to be associated with a lack of either secretion of or receptors for müllerian inhibiting substance, normally of fetal Sertoli cell origin.

21.6 Infectious Diseases Causing Orchitis and Epididymitis

Bacterial orchitis and epididymitis are far less common in goats than in sheep. Expected clinical findings include swelling, increased heat, and pain on palpation of the testis. The semen may contain pus and the percentage of live spermatozoa drops. In one case report, transrectal ultrasonography also demonstrated changes in the echogenicity of the seminal vesicles.

Coliform bacteria and *Pseudomonas* have been cultured from ejaculates of young bucks. Coliforms have caused both orchitis and epididymitis when injected into the testis. *Actinobacillus seminis* was isolated from four of 40 Angora bucks examined in South Africa, but details as to clinical presentation were not supplied (Van Tonder 1975). When pathological changes are not palpable, they might be suspected based on the presence of increased leukocytes in the semen. The major differential diagnosis is nonsuppurative sperm granuloma originating from a malformation of the epididymis.

In one five-year-old buck, unilateral testicular enlargement progressed to five times the normal size. The animal was inappetent and walked with a stiff, straddling gait. The affected testis was firm and fixed in the scrotum. *Staphylococcus pyogenes* was isolated from a purulent epididymitis at the time of unilateral castration. Involvement of the second testis was obvious within three weeks. In another report, *C. pseudotuberculosis* was associated with epididymitis and orchitis in two bucks in Brazil. *Burkholderia (Pseudomonas) pseudomallei* caused orchitis and periorchitis in a buck (Fatimah et al. 1984). The buck was inappetent and the swollen testes developed pyogranulomas. There was no response to antibiotic therapy. *Mycoplasma putrefaciens* was isolated from the testes of a buck that died during a severe herd outbreak of contagious agalactia with concomitant infection with *Mycoplasma agalactiae* and *M. putrefaciens*. Spermatozoa were absent in seminiferous tubules and there was calcification and loss of germinative epithelium, with only Sertoli cells remaining (Gil et al. 2003).

21.6.1 Brucellosis

Brucella ovis is an important cause of epididymitis and orchitis in sheep. Stamp's stain can be used to demonstrate the organism in semen smears, and white blood cells and detached heads are commonly found in the semen. This organism is not recognized as a cause of natural infections in goats.

Experimental infection of bucks by conjunctival or intrapreputial inoculation of this organism has led to clinical and histological epididymitis, transient infection, and serological response (García-Carrillo et al. 1974<<Query: AU: Reference “García-Carrillo et al. 1974” is provided in the reference list; however, this was not mentioned or cited in the manuscript. As a rule, all references given in the list of references should be cited in the main body. Please provide its citation in the body text. Ans: kindly delete>>). In a subsequent trial, the organism was isolated from the semen of one of 15 goats (García-Carrillo 1977<<Query: AU: Please cross check and verify the updated citation here “García-Carrillo 1977” Ans: kindly replace with Dadar, M., Bahreinipour, A., Alamian, S., Yousefi, A. R., Amiri, K., & Abnaroodheleh, F. (2024). Serological, cultural, and molecular analysis of Brucella from Buffalo milk in various regions of Iran. Veterinary Research Communications, 48(1), 427-436.>>). In another experiment, inoculation of *B. ovis* onto the preputial epithelium (two yearling goats) and nasal mucosa (two goats) led to an antibody response best detected by ELISA but also (in three animals) by CF testing. One intranasally inoculated buck persistently shed *B. ovis* and white cells in semen. The experiment was concluded at 98 days, when chronic epididymitis and seminal vesiculitis were demonstrated only in the goat that had excreted organisms. Thus, if bucks engage in homosexual activity with infected rams there is some potential for transmission to occur.

Brucella melitensis occasionally causes orchitis in bucks. The Rev 1 vaccine strain has also caused orchitis in a buck kid vaccinated at five months of age (Tolari and Salvi 1980). In South Africa, where the Rev 1 *melitensis* vaccine has been used to control *B. ovis* in sheep, orchitis and epididymitis have developed in Angora bucks soon after vaccination. The authors failed to create clinical disease in bucks by experimental infection with *B. ovis* and concluded that bucks should not be vaccinated unless *B. ovis* has been confirmed on the farm or *B. melitensis* is causing abortions in the herd.

21.6.2 Trypanosomosis

Trypanosoma brucei and *Tabanus vivax* have been associated with inflammatory and degenerative changes in the testis and epididymis of sheep and goats in Africa. After experimental infection with *T. brucei* (in rams), persistent scrotal edema and a nonsuppurative granulomatous periorchitis developed associated with tissue invasion by the parasite. Trypanosomes were readily detected in fluid from the scrotal sac. Secondary degenerative changes in the testis included atrophy and calcification of seminiferous tubules and intertubular sclerosis. In bucks experimentally infected with *T. vivax*, organisms were not seen outside blood vessels in the testes and it was postulated that testicular degeneration occurred because of recurrent fever. Affected animals are expected to have low fertility until some time after the infection has cleared.

Experimental infection of bucks with *Trypanosoma evansi* also caused microthrombi in testicular blood vessels, severe mononuclear cell infiltration in the epididymis and testicular interstitium, and subsequent dystrophic mineralization. The number of abnormal and dead sperm increased greatly, and bucks with clinical orchitis became aspermic. A later experimental infection of bucks with an equine isolate of the same organism caused scrotal edema in 20%, degeneration of spermatogonia and Sertoli cells, and infiltration of the testes with macrophages and lymphoid cells (Dargantes et al. 2005). Experimental infection of bucks with *Trypanosoma congolense*, a plasma parasite that does not invade tissue, also caused testicular degeneration with marked shrinking of seminiferous tubules and epididymides, but the pathogenesis is unknown.

21.6.3 Besnoitiosis

There is one report of a buck in Africa with masses of *Besnoitia* cysts in the wall and lumen of veins and arteries of the pampiniform plexus; parasitic cysts were also present in the epididymis and testis. Thrombosis of vessels, absence of sperm production, and extensive testicular fibrosis were believed to be caused by the parasite. Encrustation of the scrotum and presence of numerous *Besnoitia* cysts in the tunica vaginalis, tunica albuginea, and interstitium of the epididymis were reported from two male wild goats in Iran. The existence of a distinct species, *Besnoitia caprae*, has been proposed in Kenya, where cattle housed with infected goats do not develop besnoitiosis (Figures 21.3 and 21.4).

Figure 21.3 Sperm granuloma (epididymis exhibiting multiple sperm granulomas).

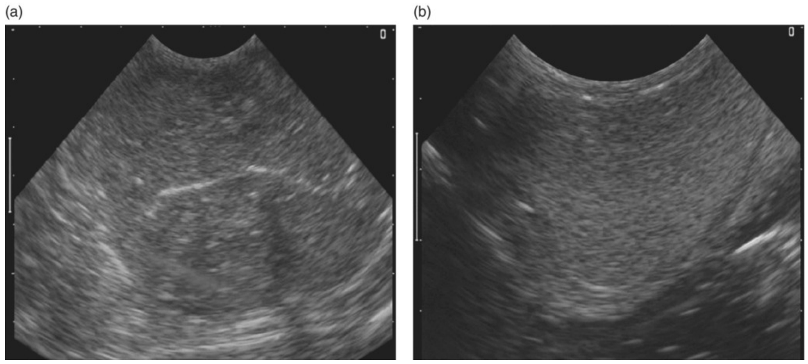

Figure 21.4 Irregular echogenicity indicates testicular pathology such as orchitis, degeneration, or neoplasia (a) and homogeneous appearance of normal testicular tissue (b).

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