Reproductive anatomy and physiology of whitetail deer and other select cervids, sheep and goats

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Introduction

Understanding the basic anatomical and physiological characteristic of breeding stock of the cervid and small ruminant is essential for a successful breeding program. This knowledge will insure that the males and females are in the correct stage of their reproductive cycle in the proper season for the appropriate timing of an insemination. Although this can be somewhat difficult in the cervids as there is such a large number of species and subspecies that vary in their physiologic nature. This article will concentrate on white tailed deer and elk as the major cervid species.

Keywords: Cervid, sheep, goat, anatomy, physiology

Anatomy of the female cervid and small ruminant

The reproductive anatomy of cervids and small ruminants overall are not that different. The major anatomical structures of the female cervid and small ruminant reproductive tract are quite similar.[1] The major components include: the ovaries, oviducts, cervix, vagina, and vulva and clitoris.[2] The external genitalia consists of the vulva, which has two labia that are marked by dorsal and ventral commissures, and the tissue that is similar to the erectile penis, the clitoris.[1] Just cranial to the clitoris is the vestibule. It is lined with stratified squamous epithelial cells and mucus producing glands located on the walls and sometimes floor of the vestibule.[1,3] These glands are not present in the goat and are most times located near the urethral orifice in the ewe.[1] Another unique anatomical feature of the ruminant vestibule is the presence of the suburethral diverticulum that opens in the external urethral orifice. This blind sac is 2 cm deep and located behind the urethral orifice and can make catheterization of the urinary bladder difficult.[3]

The inside of the vagina is also lined with stratified squamous epithelium and measures approximately 10-15 cm in length in small ruminants. The cervix is located at the most cranial portion of the vagina. The small cervix has 5-8 (5-6 in the ewe and 5-8 in the doe; 4-6 in the deer and wapiti) irregular overlapping folds within the lumen and is not easily dilatable.[4] The lumen can be quite narrow and tortuous to maneuver during assisted reproductive techniques.[1,3]

The uterus is bicornuate and composed of a short body and two uterine horns that range from 6.5 to 15 cm in length in the nongravid state in all of the small ruminants and cervids.[3,4] The lumen of the uterus is lined with endometrium (mucosa) with folds that form convex caruncles that serve as attachment sites for the cotyledons of the fetal placenta.[1,3]

The uterine horns are connected to the ovaries by the oviducts. The ovaries are typically small (1-2 cm) and oval in shape. In the nonbreeding season, they can be somewhat circular and smooth on the surface. During the breeding season, the surface of the ovaries are uneven and rough due to the development of numerous follicles and corpora lutea (depending on the species) and sometimes double in their overall size.[1,3,4]

Anatomy of the male

The reproductive organs of the male consist of the testes, epididymides, ductus deferens, spermatic cords and tunics, accessory sex glands, penis and prepuce.[1,3] The testes are oval to spherical in shape and can vary in size depending on season and hormonal influence. In the ram, the testes weigh between 200-250 g and the 130-160 g in the buck.[3] The testes are located in the pendulous scrotum between the hind legs–they appeared to be held closer to the body in the cervid species compared to domestic small ruminants. The scrotum of the small ruminant can be covered by wool or hair and needs to be considered when examining these structures.

The body of the epididymides is located laterally and ends caudomedially to the testes in small ruminants and is oriented so that the head of the epididymis is proximal and the tail is distal to the

corresponding pole of the testis.[1,3] The tail of the epididymides flow into the ductus deferens and their distal ends enlarge to form the ampullae. The accessory sex glands of the small ruminant and cervid male include paired ampullae, paired vesicular glands, both a body and disseminate part of the prostate, and small bulbourethral glands.[1,5] Many of these glands will increase the height of the epithelial cells lining the mucosa in response to seasonal influences in preparation for the breeding season.

The male cervid and small ruminant has a fibroelastic penis with a urethra that is covered by corpus spongiosum penis throughout its length and is composed of three parts.[1] The base (root) of the penis is attached to the ischial arch, the shaft (main portion of the penis), and the glans penis. The shape of the penis is a simple rod shape that does not increase much in circumference during erection, but does increase in length by approximately 40%.[5] When the penis is not erect, the ram or buck penis is normally held in a S-shaped bend (sigmoid flexure) by the retractor penis muscles.[1] The penis of the wapiti bull does not contain a sigmoid flexure.[5] In the ram and buck, the glans penis has a specialized distal end of the penis that contains a urethral process or vermiform appendage.[2,3] The only unique feature to the wapiti bull penis is the upward pointing direction of the distal urethra used for directing urine onto the ventral abdomen, neck and throat regions during the rut season.[5]

Physiology of cervids

When referring to cervids in North America there tends to be a concentration on the species that are farmed: white tailed deer, wapiti (elk), red and sika deer. There are many species and numerous more subspecies of cervids that exhibit a variety of different physiologic behaviors and patterns for their reproductive cycles – "no one species can be considered to represent a 'typical' deer in terms of reproductive function".[6] Depending on the classification of cervid, they could exhibit reproductive cycles in a seasonal pattern or are aseasonal and some can bear multiple offspring while others give birth to a single offspring. An example of the "r- selected" species is the white tailed deer. These cervids are the small-bodied animals that are relatively territorial, live in the forest, exhibit a short breeding life (< 10 years), and produce multiple offspring. The "K-selected" species tend to be more seasonal in their breeding patterns and produce singletons and have a longer breeding life than the other species.[6] Examples of these cervids include red deer, wapiti, sika deer, and reindeer. There is more known about the reproductive cycles of the "K-selected" species due to their nature and ability to adapt to human management.

Seasonality

The majority of cervids studied in North America follow similar patterns to other short day breeders like sheep and goats. They will conceive in the months where day length is decreasing and give birth in the months when the days are becoming longer.[7] Differences in the actual mating seasons can vary up to eight weeks and can be due to variations in the duration of gestation between various species. There are many other species of cervids that live in tropical climates and cycle throughout the year and do not follow the any seasonal pattern as there is less of a seasonal influence of the environment and available food supply for rearing offspring.[6]

Physiology of the female cervid

The white tailed deer is seasonally polyestrous and breeds during short day length. The decreasing day length sends a signal to the pineal gland to produce melatonin, which stimulates gonadotropin releasing hormone (GnRH) secretion.[2] The GnRH via luteinizing hormone (LH) and follicle-stimulating hormone initiate follicular development and the one or two subsequent "silent" ovulations (ovulations not preceded by overt estrus) that are then followed by regular estrous cycles that will continue for the next four to six months if the female is not impregnated.[8,9] The length of the estrous cycle is 25-28 days. The length of the estrous cycles for red deer is 18 days and for wapiti is 21 days.[4] The period of rut is influenced by geographical regions and seasonal environment. Doe fawns are influenced by their birth date and body weight as to the initial period when they enter puberty and an estrus period. If the nutrition is adequate for the does to reach 70% of their adult body weight in the first

autumn of their life, then they will come into estrus in year one.[4] Additionally, they may not come into estrus during the first rut of the breeding season as the more dominant does will be bred during this time period and they are allowed to exhibit estrous behavior and be bred during the second rut of the season.[*]

Ovulation occurs approximately 24 hours after the onset of estrus and is very similar to the timing of sheep and other small ruminants (Table). In the preovulatory period, the brain of the female needs to be "primed" with progesterone so that it is sensitive to the estrogen produced by the ovaries. As described previously, if this progesterone is not present prior to follicular development and ovulation, a "silent" ovulation will occur and no behavioral signs of estrus will be exhibited.[2,9] Once the female has formed mature corpora lutea and appropriate progesterone levels, the brain can respond to the estrogen and behavioral estrus can be exhibited. Female cervids, particular hinds, do not show many of the same signs of overt estrus as is seen in ewes and does, there is little or no vulvar swelling.[9] Depending on the proximity to ovulation, the frequency of mounting activity can vary for each female, but hinds do not usually mount other hinds but will mount the stag. Generally it is thought that the close proximity of a hind to the stag indicates her receptivity to be bred.[9] Estrus behavior terminates when the female is bred or when the day length begins to increase again. An anestrous period occurs annually for about four to six months after the spring equinox similar to other short day breeders such as sheep and goats.

Table. Reproductive characteristics of select female cervids and sheep and goats

Species	Age at Puberty	Length of Estrus	Length of the Estrous Cycle	Gestational Length
Ovine (ewe)	6-9 months	30 h (18-48 h)	17 d (13-19 d)	142-152 days
Caprine (doe)	6-8 months	36 h (24-72 h)	21 d (18-24 d)	145-150 days
White tail deer (doe)	1 ½ years[†]	12-24 h	25-28 d	200 days
Wapiti (hind)	1 ½ years[†]	12-24 h	21 d	242-252 days
Red deer (hind)	1 ½ years[†]	12-24 h	18 d	230-236 days

[†]Age at puberty is dependent on nutrition and can be delayed until they are 2 ½ years old

Physiology of the female sheep or goat

From a pure physiologic point of view, sheep and goats are quite similar to female cervids in their seasonality of breeding and responsiveness to decreased day length. The lengths of the estrous cycles are different: 17 days in the ewe and 21 days in the doe.[1,2] They have a seasonal anestrous period that can vary amongst breed and climate. The majority of breeds will show a similar yearly transition from anestrus to seasonal cyclicity as the brain of the female undergoes "priming" by progesterone.[2] There are some (as there are in various species of cervids) that are not influenced by season, and usually live in more tropical climates, that will continue to exhibit estrous cyclicity throughout the year.[1] Additionally, the first estrous cycles of each breeding season tend to be shorter than those at the middle to end. This is attributable to hormonal influence and stimulation by the decreased day length and melatonin production.[1,2]

[*] Shipley CF. College of Veterinary Medicine at the University of Illinois at Urbana-Champaign, Urbana, IL, personal communication.

Estrus behavior has been observed and studied more in sheep and goats than in cervids, likely due to their proximity to humans. Signs of estrus in the sheep include vulvar swelling with a copious thin vaginal mucous secretion and anorexia.[1,10] Ewes will ovulate 14-26 hours after the LH surge (toward the final third of estrus) and the length of estrus will likely be breed dependent – wood breeds having longer estrus than meat breeds.[1] There does not seem to be a similar phenomenon in goats breeds – they are more influenced by nutrition and milk production (especially in dairy breeds) in the length of estrus.[1] The length of estrus in the doe varies from 24 to 72 hours, with ovulation occurring 12-36 hours after the onset of standing heat. As with all of the females discussed, ovulation and expression of estrus can be hastened by the presence of a mature male. Does may not exhibit homosexual mounting behavior, but they will have vulvar swelling and have a clear mucus discharge that becomes cloudy towards the end of estrus.[1,11] They will exhibit unique tail flagging activity that is described as "rapid side-to-side and up-and-down" movements of the tail that serves to spread pheromones from the doe's vulva to any males that are nearby.[11] Additionally, they will vocalize more than usual and tend to be more restless and increase their urination frequency to help attract the male.[1,11]

Physiology of the male

Puberty in the male is defined as "the point at which the male develops an interest in sexual activity and produces spermatozoa in sufficient numbers to achieve pregnancy".[1] The exact age at which this occurs is dependent on the age and breed of the male. In seasonal breeders, males that are born in the spring of the year tend to enter into puberty earlier than males born in the autumn. As the majority of cervid males and rams and bucks are seasonal breeders, they will exhibit signs of puberty in the first autumn when their body weight is 70% of their mature weight. Additionally, males that are exposed to cycling females before their first puberty will exhibit signs earlier.[1] Rams are much more influenced by the season than are bucks, but they will tend to express a lower libido, less odor and reduced scrotal circumference in the fall of the year.[12] A unique feature to the buck is that he will not be able to copulate with a female until his glans penis is free of attachments between the prepuce and the penis.[1,12] In most bucks, these attachments are completely gone by four to five months of age. For wapiti and deer, puberty is not only influenced by season and reaching a critical weight, but also by growth of his first set of antlers. Puberty will be halted during the growth of the antlers, but will resume again at about 13-14 months of age.[4]

Puberty and the normal breeding season are all influenced by decreasing day length in these species. As the length of the day decreases, LH levels rise and stimulate testicular development via growth of the Leydig cells. The Leydig cells in turn increase production of testosterone and influence spermatogenesis.[2,8] The males will remain fertile throughout the breeding season and produce adequate levels of spermatozoa until the early spring when the days begin to increase in length as long as there are no other factors that affect the males' fertility.

Antler growth is a unique feature of the cervid male and is under the influence of hormonal (testosterone) control. A young growing male has antlers that are covered with a highly vascularized and sensitive skin known as velvet. As the mating season approaches, serum testosterone levels increase and the antlers harden and the velvet dries. Stags will rub their antlers against objects such as trees to remove the dried and flaking velvet. Once the mating season has concluded, a layer of bone-dissolving cells invades the base of the antlers, causing them to fall off. Each year the size and the complexity–depending on the species–increases until the stag reaches full maturity.[8]

Sexual behavior of the male appears to be influenced by decreasing day length and is increased as the females begin exhibiting overt signs of estrus. Most of the males will begin a courtship behavior with the female and will display a typical flehman response after sniffing the vulva region and urine of a female in estrus.[1] The buck (or ram) will deposit semen in the anterior vagina of the female during a natural breeding event.

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