Bull Breeding Soundness Examination; What is New?
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Introduction

The term “breeding sound” is frequently used to describe a bull’s ability to get cows pregnant and all too often there is a broad range of expectations when this term is used. In the narrowest sense, a bull that is capable of getting one cow pregnant is breeding sound, however, unless that bull is capable of getting a reasonable number of cows pregnant during a limited breeding season he is not an efficient sire. This presentation discusses the economics and current status of breeding soundness in bulls.

High reproductive efficiency is the most economically important factor for success in cow-calf enterprises having greater dollar impact than growth rate, feed efficiency, and carcass quality. In order to be profitable each cow on a farm or ranch should raise a calf to weaning each year. Performing bull breeding soundness evaluations prior to breeding is one tool that helps ensure that only bulls with a high likelihood of achieving pregnancy will be utilized.

Breeding soundness evaluations categorize bulls as either, likely fertile, likely subfertile, or sterile. The current standards of the Society for Theriogenology provide a uniform method of assessing a bull’s likelihood of accomplishing pregnancy in 25 or more open, healthy, cycling cows in a 65-70 day breeding season. It should be emphasized that there are very few sterile bulls and that most bulls will eventually get most cows pregnant if left together a sufficient period of time. However, such unlimited breeding seasons deny the producer the opportunity to
take advantage of labor, health maintenance procedures and marketing opportunities. Equally important is the considerations for animal well-being such as cows being repeatedly mounted and bred before becoming pregnant, calves born in suboptimal environmental conditions that compromise their health and survivability, and the potential for injury in bulls with low breeding efficiency.

The first selection and culling of bulls is generally at weaning when they are 7 to 10 months old. Relatively few calves clearly display abnormal development and conformational traits at this age and consequently most culling is based on the breeder’s assessment of the bull’s growth potential. The main reproductive criterion for selection of bulls at this age is testicular development. Yearling bulls with small testicles are not likely to catch up over time and still have small testicles at two years of age. Young bulls with small testes should be culled as they have a low probability of attaining adequate scrotal circumference by 1 year of age and daughters of these bulls will reach puberty later than daughters sired by bulls with large scrotal circumference for their age. Scrotal circumference (SC) measurements in weaned bulls are helpful to predict yearling SC. Simmental, Angus and Zebu derived bulls, predominantly Santa Gertrudis, must have a minimum SC of 23 cm at 198-291 days of age to have a nearly 100% probability of attaining $\geq 30$ cm SC by 365 days of age. Other continental breeds, predominantly Charolais, and Polled Hereford bulls require $\geq 26$ cm SC to reach $\geq 30$ cm SC by 365 days of age. If minimum requirements for SC are increased to 32 cm at 356 days of age, an additional 2 to 3 cm would be needed at weaning. Coe and Gibson evaluated 264 bulls representing 13 beef breeds and found that at 200 days of age calves with SC $> 23$ cm had a 95% probability of
achieving SC >34 cm by 365 days of age whereas calves with SC <23 cm only had a 54% probability of achieving SC >34 cm by 365 days.

The minimum threshold for scrotal circumference is based upon age of the bull. Those thresholds are as follows:

<table>
<thead>
<tr>
<th>AGE</th>
<th>THRESHOLD</th>
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<tr>
<td>≤ 15 months</td>
<td>30 cm</td>
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<tr>
<td>&gt;15 to 18 months</td>
<td>31 cm</td>
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<tr>
<td>&gt;18 to 21 months</td>
<td>32 cm</td>
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<tr>
<td>&gt;21 to 24 months</td>
<td>33 cm</td>
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<tr>
<td>&gt;24 months</td>
<td>34 cm</td>
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**Classification for Breeding Soundness**

Following evaluation according to the SFT criteria bulls are classified according to their suitability for breeding on the day of evaluation. Those bulls that are conformationally sound, free of ocular and musculoskeletal defects and that produce at least 70% morphologically sperm that are at least 30% progressively motile are classified as Satisfactory Potential Breeders (Potentially Fertile). Bulls that do not meet these criteria are placed in one of two categories. Those bulls with temporary conditions which are likely to resolve and allow the bull to meet the above thresholds are placed in the category of Classification Deferred (Subfertile). Bulls in this category are usually juvenile, have an injury or lameness that is likely to resolve or suffer from summer heat induced testicular degeneration. If this classification is used the veterinarian should recommend a date for re-evaluation of the bull. Bulls with undesirable heritable defects, small scrotal circumference that do not meet the minimum for their age, debilitating injury or disease, or with permanent testicular degeneration should be classified as an Unsatisfactory Potential Breeder (Potentially Sterile).
Summary

There are very few sterile bulls in the cattle population. If allowed sufficient time, most bulls will eventually achieve nearly 100% pregnancy in a herd of fertile, healthy females. However, the goal of the breeding soundness examination is to identify bulls with a high likelihood of getting a large percentage of females pregnant in a controlled breeding season. Most authors agree that a bull considered to be a satisfactory potential breeder by routine breeding examination should get 25 - 35 cows pregnant in 70 days. A breeding soundness examination does not reflect a bull’s soundness in the past nor does it define the bull’s future ability to cause conception. It does allow a prediction of the bull’s current potential fertility and the overall effect is to improve the genetic base for fertility within herds or breeds.

If fertile bulls in good health and physical condition are exposed to fertile, healthy, cycling cows first service conception rate averages 60 - 65%. Therefore of 100 cows exposed, 35 will not be pregnant after one service. After a second service, an additional 65% of those cows (35 cows x 65% = 23) would be pregnant). After a third service, an additional 65% of the remaining 12 open cows would be pregnant (12 cows x 65% = 8). A total of 94 cows should be pregnant after 3 cycles.

However, if we expose bulls that have not been categorized according to fertility to the same cows, only about 55% first service conception rate is expected with about 88 cows pregnant after 3 cycles. Subfertile bulls may only achieve 40% first service conception rate such that only 78 cows become pregnant with 3 cycles.
This presentation will review the economic impact of utilizing fertile bulls on herd production and owner income as well as status of current ancillary testing for bull breeding soundness.

References:


2. www.therio.org


Update on Bull Management and Biosecurity with Special Emphasis on Trichomoniasis
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Abstract

Biosecurity for the breeding herd is critical for avoidance of infectious causes of infertility and introduction of bulls if frequently the most likely avenue of introduction of disease. Bovine trichomoniasis, Camplyobacteriosis, Bovine Viral Diarrhea Virus (BVDV), Infectious Bovine Rhinotracheitis Virus (IBR) and Leptospirosis are common causes of infectious infertility in the United States that may be introduced into the herd through bull additions. This paper outlines common guidelines for the prevention and control of infectious infertility, the pathogenesis, prevalence, economic impact, and diagnosis of trichomoniasis in cattle.

What is biosecurity? One definition is actions to prevent the introduction or spread of diseases with the goal of keeping livestock healthy and free from exposure to infectious agents. Biosecurity is largely controlling the movement of people, fomites, and animals to prevent disease transmission. Livestock trailers, truck tires, boots and equipment are sources of introduction of disease. BVDV, Leptospirosis, and Johne’s disease are readily transmitted by contaminated equipment to susceptible animals. A minimum 30 day quarantine should be mandatory for new herd additions. Additionally, eliminating the source of disease is critical. Testing for Trichomoniasis is a tool to achieve that goal. Testing for additional diseases of interest to the farm or ranch may also be indicated.

Introduction
Trichomoniasis is a substantial cause of fetal wastage resulting in economic losses in natural breeding systems. Infected bulls are usually asymptomatic carriers of *Trichomonas foetus* (*T. foetus*) but are capable of transmitting the organism to a cow or heifer during coitus. Infections in cows and heifers may result in early embryonic death, abortion, pyometra, fetal maceration, or infertility,\(^1\text{-}^4\) negatively impacting the economic success of a cattle operation. Economic losses are due to reduced calf crop from early embryonic loss or abortion, reduced weaning weight due to delayed conception; and culling and replacement of infected cattle. Currently there is no legal treatment for this infection in the United States (U.S.) therefore veterinarians and cattle producers must focus on preventive management and other control measures. Understanding the pathogenesis, prevalence, economic impact, and diagnosis of trichomoniasis will assist with implementation of appropriate prevention and control programs.

**Pathogenesis and clinical signs**

In bulls, *T. foetus* localizes in the smegma of the epithelial lining of the penis, prepuce, and distal urethra.\(^5\) *Trichomonas foetus* causes no penile or preputial lesions and does not affect semen quality or libido.\(^5\text{-}^6\) An infected bull, therefore, acts only as an asymptomatic carrier, and rarely clears the infection regardless of time. Deep preputial and penile epithelial crypts provide the appropriate microaerophilic environment required for establishment of chronic infections and a common belief is that *T. foetus* infections in young bulls (less than 3-4 years of age) tend to be transient.\(^5\text{-}^7\text{-}^9\) However, any bull exposed to *T. foetus* in a natural breeding situation is capable of becoming chronically infected, regardless of age.
Trichomonas foetus infection in the cow occurs during coitus with an infected bull. The organism transverses the cervix and colonizes the entire reproductive tract within 1-2 weeks, and as the organism multiplies in the uterus it can cause death of the embryo or fetus, most commonly between gestational days 15 to 80. A small percentage of cows will not abort until the second or even third trimesters, and an even smaller number of cows (less than 1%) will maintain an infection through a normal gestation and deliver a live calf. The few cows that maintain a T. foetus infection throughout gestation and into the next breeding season are very damaging since they represent a source of re-infection for the herd. Pyometra and abortion are often the first physical signs of trichomoniasis noticed in a herd, but these signs occur in less than 5% of infected animals. Infertility due to embryonic death is the most economically damaging symptom and occurs in a larger percentage of infected cows. An affected cow’s estrus interval is usually prolonged because the embryonic loss typically occurs after maternal recognition of pregnancy (days 15-17 of gestation).

Unlike the bull, the cow typically mounts an effective immune response to T. foetus, but the time it takes to clear T. foetus from the cow’s reproductive tract is quite variable. Primary infections may be cleared from the reproductive tract in as little as 95 days or as long as 22 months. Subsequent infections are cleared in about 20 days, indicating an anamnestic response. Immunity does not persist, however, and the anamnestic response is only significant if re-infection occurs within about 15 months of the primary infection. A cow in a herd with a long breeding season could therefore become pregnant and infected with T. foetus early in the breeding season, lose that embryo, be infertile for several months, clear the initial T. foetus infection, rebreed, conceive, and carry a calf to term as a result of temporary immunity. The result is that more cows will calve later in the calving season than desired resulting in wide
variation in weaning weights rather than just a reduced calving percentage. The later born calves are then marketed at lighter weights, or the cattle producer will incur increased feeding costs to achieve a desired market weight. In either case the producer sustains substantial economic losses.

**Prevalence**

Estimates regarding prevalence of trichomoniasis in different regions of North America have been published. In 1964, Johnson reported a 7.5 % prevalence in western range bulls. More recent studies from Florida, Oklahoma, and California found prevalence rates of 7.3, 7.8 and 4.1 %, respectively. The Florida and Oklahoma studies sampled bulls from sale barns or abattoirs, while the California study sampled bulls from randomly selected herds. Rae et al conducted a more recent epidemiological survey of randomly selected natural service beef herds in Florida between 1997 and 1999, and reported a 6 % prevalence of *T. foetus* infected bulls. Riley et al also reported a 6 % prevalence in bulls in Saskatchewan, Canada. In other parts of the world, Erasmus et al reported a 7 % prevalence in the North Western Cape Province, Western Transvaal, and the Orange Free State in South Africa.

**Economic impact**

The economic impact of trichomoniasis is due to: 1) reduced calf crop from early embryonic loss or abortion; 2) reduced weaning weight due to delayed conception; and 3) culling and replacement of infected cattle. Rae developed a computer simulation model to study the impact of trichomoniasis on a cow-calf producer’s profitability. The model estimated a 14 to 50
% reduction in annual calf crop if *T. foetus* infections were present in 20 to 40 % of the bull population, and the net return per cow exposed to an infected bull decreased by 5 to 35 %. The economic impact of trichomoniasis can be so devastating that several western states in the U.S. consider trichomoniasis a reportable disease and require bull testing prior to sale, prior to transport into the state, or before the use of public land.

**Diagnosis of Bovine Trichomoniasis**

Diagnosis of *T. foetus* has traditionally relied upon microscopic identification of key morphological characteristics in preputial smegma or cervicovaginal mucus (CVM) incubated in various culture media. Such characteristics include three anterior flagella, one posterior flagellum, and an undulating membrane resulting in a jerky movement pattern. However, accurate microscopic identification of *T. foetus* can be complicated by the presence of other trichomonadid protozoa. Contamination of the preputial orifice, prepuce, or penis with fecal material probably explains the presence of these opportunistic trichomonads. Several non-pathogenic protozoa are normal inhabitants of the bovine gastrointestinal tract, and therefore proper cleaning of the preputial orifice and proper sampling techniques are critical to avoid fecal contamination of diagnostic samples. None of the contaminating trichomonads, however, results in reproductive pathology in cows or bulls. Therefore, research has recently focused on molecular-based assays to accurately differentiate *T. foetus* from other trichomonads. Given the lack of legal therapy for bulls infected with *T. foetus*, the only reasonable course of action is to slaughter an infected bull. It is therefore imperative to correctly identify *T. foetus*-infected bulls and not misdiagnose based on the presence of non-pathogenic fecal trichomonads.
Currently molecular-based assays are most commonly used as confirmatory tests for bovine trichomoniasis because of the relatively low cost of \textit{in vitro} culture compared to molecular-based assays. However, molecular-based assays are very effective in diagnosing human trichomoniasis caused by \textit{Trichomonas vaginalis}, with a sensitivity of 95 \% and a specificity of 98 \%\textsuperscript{35} and it is therefore very likely that the future preferred diagnostic test for bovine trichomoniasis will be a molecular-based assay. Some researchers already advocate their use as an independent diagnostic test for bovine trichomoniasis.\textsuperscript{36,37}

\textit{Sampling techniques in the male}

Several sampling techniques are utilized for obtaining diagnostic specimens in the bull including: 1) a swab technique;\textsuperscript{38} 2) a dry pipette technique;\textsuperscript{15,39} 3) a wet pipette technique;\textsuperscript{40} and 4) the douche technique.\textsuperscript{40} Fitzgerald \textit{et al} compared the swab and pipette techniques and reported that the number of parasites recovered via the swab technique is only 20 \% of the number of parasites recovered via pipette scraping.\textsuperscript{41} The swab technique is therefore rarely used in the United States. The dry pipette technique is one of the most common sampling methods in the U. S., while the douche method is the preferred technique in Europe.\textsuperscript{39} Schönmann \textit{et al} reported that the two methods are not statistically different.\textsuperscript{39}

Regardless of technique used, it is generally recommended that bulls be sexually rested 1-2 weeks before testing for \textit{T. foetus}; otherwise, false-negative results are more likely because breeding mechanically removes many of the organisms from a bull’s penis and prepuce. Given the sensitivity of \textit{T. foetus} cultures, false-negative results are also possible even if a bull has been sexually rested. Only with three negative tests at weekly intervals (Figure 1) can a veterinarian or producer be 99 \% sure that a bull is \textit{T. foetus} negative.\textsuperscript{42}
<table>
<thead>
<tr>
<th>Test</th>
<th>Result</th>
<th>Sensitivity (in series)</th>
</tr>
</thead>
<tbody>
<tr>
<td>First test</td>
<td>Negative</td>
<td>80 %</td>
</tr>
<tr>
<td>Second test (one week later)</td>
<td>Negative</td>
<td>96 %</td>
</tr>
<tr>
<td>Third test (one week later)</td>
<td>Negative</td>
<td>99 %</td>
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Figure 1. Sensitivity (in series) of *T. foetus* cultures.\(^{42}\)

**Sampling techniques in the female**

The technique most commonly used to sample female cattle for *T. foetus* is a dry pipette technique\(^8,15,40\) in which an infusion pipette is used to aspirate cervicovaginal mucus (CVM) from the vaginal fornix or near the external cervical os. Alternatively, in the case of a post-coital pyometra, an infusion pipette can also be used to aspirate some of the content of the pyometra. Either sample is then examined directly or placed into appropriate culture medium. Culturing *T. foetus* from cervicovaginal mucus has a reported sensitivity of 58 to 75 %.\(^{43}\) Samples can also be evaluated with appropriate molecular-based assays.

**In vitro culture**

Direct microscopic examination of specimens for *T. foetus* is diagnostic, but a far more sensitive method for the detection of *T. foetus* is *in vitro* culture of preputial smegma or CVM in a selective nutrient medium for up to a week.\(^{43-45}\) *In vitro* culture allows the proliferation of *T. foetus* to more readily detectable levels. All cultures containing organisms resembling *T. foetus* should be confirmed with appropriate molecular-based assays to avoid false-positive results due to fecal trichomonad contamination of culture media.\(^{24,25,46}\) Alternatively, samples may be submitted directly for molecular-based evaluation.
**In vitro culture media**

Various culture and transport media systems have been used but Diamond’s medium, and most recently the InPouch™ TF\(^8\) *Trichomonas foetus* culture pouch are most commonly used in the United States. Both culture systems are fairly equal in sensitivity\(^8,39,47,48\) although the InPouch™ TF is somewhat more convenient than Diamond’s medium.\(^49\) The InPouch™ TF has a 12-month shelf-life at room temperature, compared to a much shorter refrigerator-life for Diamond’s medium. Also, the plastic pouch design of the InPouch™ TF is less likely to break or leak than tubes containing Diamond’s medium. Unfortunately, the InPouch™ TF is more expensive than Diamond’s medium.

For many years, cultivation of microorganisms with motility and morphology resembling *T. foetus* in either the InPouch™ TF or Diamond’s medium was considered to be 100 % specific. However, accurate microscopic identification of *T. foetus* has since been shown to be complicated by the presence of other contaminating trichomonad protozoa.\(^24-28\) All cultures containing organisms resembling *T. foetus* should therefore be confirmed with appropriate molecular-based assays, or samples should be submitted directly to a laboratory for molecular analysis. Contact the laboratory prior to sample collection to verify the appropriate transport medium.

**Treatment**

One of the complicating factors associated with bovine trichomoniasis is that there are currently no effective treatments with U.S. Food and Drug Administration approval.\(^15\)
Historically, the most successful treatment for bulls with trichomoniasis involved systemic treatment with nitromidazole derivatives. However, the use of nitromidazole derivatives is now illegal in food-producing animals in the U.S. because of their mutagenic and carcinogenic properties, and no alternative treatments are available. The lack of effective approved therapies for bovine trichomoniasis emphasizes the need for appropriate preventive and control measures.

**Prevention and Control of Bovine Trichomoniasis**

Preventing the introduction of *T. foetus* into a cattle herd and controlling trichomoniasis in an infected herd follow many of the same management strategies, and to a large extent focus on herd biosecurity. Ideally, every cattle operation should focus on preventing the introduction of *T. foetus*.

Recommended practices to prevent the introduction of *T. foetus* into a cattle herd include:

1) When possible, avoid grazing cattle on public lands where both bulls and cows have a much greater risk of exposure through coitus with other *T. foetus*-infected animals.

2) Utilize artificial insemination when possible.

3) Cull all open cows and heifers.

4) Control animal movement into a herd. Maintain good fences to prevent *T. foetus*-infected animals from inadvertently entering a herd, or to prevent uninfected animals from temporarily entering a *T. foetus*-infected herd and then returning with *T. foetus* to their uninfected herd of origin.
5) Purchase virgin bulls and heifers as replacements. Buying older bulls and cows as replacements greatly increases the chance of purchasing a *T. foetus*-infected animal. While older bulls are much more likely to become chronically infected with *T. foetus* than cows, a small percentage of cows will also become chronically infected.\(^6\)

6) Test bulls for *T. foetus* at least once before introducing them into a new herd.\(^1\) The test should be performed after two weeks of sexual rest. Ideally, a bull should have three negative cultures at weekly intervals.

7) Maintain as young a bull battery as possible. Older bulls are considered more likely to develop chronic *T. foetus* infections.\(^5,54\) However, any bull exposed to *T. foetus* in a natural breeding situation is capable of becoming chronically infected, regardless of age.

8) Breed purchased cows and heifers in a separate herd, and cull all open animals. Ideally, continue to keep the pregnant animals segregated from the rest of the herd through the next breeding season.\(^4\)

9) Consider immunization against *T. foetus* in high-risk herds.

Recommendations for control of trichomoniasis in an infected herd includes:

1) Test and cull all infected bulls. Infected bulls should be sold for slaughter only.

2) Decrease the number of bulls per breeding unit. Single-sire herds offer the lowest exposure potential. However, single-sire units may not always be practical.

3) Reduce the average age of the bull herd. Older bulls are considered more likely to develop chronic *T. foetus* infections.\(^5,54\) However, any bull exposed to *T. foetus* in a natural breeding situation is capable of becoming chronically infected, regardless of age.
4) Test bulls for *T. foetus* at least once before introducing them into a new herd.\textsuperscript{15} The test should be performed after two weeks of sexual rest. Ideally, a bull should have three negative cultures at weekly intervals.

5) Utilize artificial insemination when possible.\textsuperscript{15}

6) Reduce the breeding season to less than 90 days and cull all open cows and heifers. If there are too many open cows for culling to be economically feasible, then at least these animals should be separated into a high-risk herd. A long breeding season not only allows propagation of *T. foetus*, but it may also hide production losses due to reduced weaning weights because of delayed conception.\textsuperscript{55}

7) Culture all pyometras diagnosed in cows or heifers during pregnancy examinations.

8) Submit all aborted fetuses and placental tissue to a diagnostic laboratory.

9) Immunization against *T. foetus* is an extremely important management tool for herds infected with *T. foetus*. Research trials clearly demonstrate the benefit of *T. foetus* vaccination.\textsuperscript{56-61} TrichGuard\textsuperscript{b} and TrichGuard\textsuperscript{c} V5L are currently the only *T. foetus* vaccines available in the United States. The vaccines require an initial subcutaneous dose followed by a booster dose two to four weeks later. The second injection should precede the breeding season by four weeks. Annual revaccination four weeks prior to the breeding season is recommended.

### Endnotes

\textsuperscript{a} InPouch™ TF *Trichomonas foetus* culture pouch – BioMed Diagnostics, White City, OR

\textsuperscript{b} TrichGuard® – Fort Dodge Animal Health, Fort Dodge, IA

\textsuperscript{c} TrichGuard® V5L – Fort Dodge Animal Health, Fort Dodge, IA
Reference List


**Introduction**

The inability of a male to reproduce due to inability to reproduce is called *impotentia generandi*. This infertility may be due to inability to achieve erection, *impotentia erigendi*, inability to complete coitus, *impotentia coeundi*, or the inability to produce an adequate volume of morphologically normal progressively motile sperm. This presentation will discuss physical causes that limit a bull’s ability to complete coitus.

**Examination of the penis and prepuce**

Examination of a bull for inability to breed begins with a thorough history and physical exam followed by full examination of the reproductive organs. Examine the penis and prepuce of bulls from a distance followed by manual examination with the bull safely restrained in a chute with a drop side. The conformation of the sheath is important and the distal end of the sheath should be no longer than a line drawn from the hock to the carpus. The distal end of the sheath, the preputial orifice, should not be excessively large and the angle of the sheath should roughly approximate a line drawn along the ventral aspect of the sheath which intersects the lower front leg or foot. With the bull in a chute apply moderate pressure on the bull’s sides with the chute squeeze mechanism and place a sturdy bar behind him to limit his ability to kick during the examination. The preputial hairs should be free of calculi, exudate, or hemorrhage. The penis
and prepuce should be contained within the sheath although naturally polled bulls may have a slight prolapse of the prepuce when they are relaxed. Palpate the entire penis through the sheath for swelling or fibrous tissue. Preputial abscesses are usually circumscribed swellings along the midportion of the sheath and penile hematoma produces swelling on the dorsum of the penis at the distal bend of the sigmoid flexure. Swelling due to penile hematoma is usually symmetrical along the long axis of the penis while retropreputial abscess is usually located more along one side of the penis. Generalized swelling within the sheath along the penis is due to cellulitis from preputial laceration or from urine contamination of the peripenile elastic tissue.

With the aid of an assistant manually extend the penis, grasp the free portion of the penis with a dry surgical sponge and complete penile extension. The skin of the penis should be moist and pink with no evidence of swelling, vesicles, pustules, papillomas, lacerations or scar tissue.

**Anatomy and physiology of erection**

Erection in the bull occurs when blood flow increases in the deep artery of the penis and into the crus penis and subsequently into the corpus cavernosum penis (CCP) following olfactory or visual sexual stimulation. The CCP in the bull is a closed system in that erectile blood flows into the penis from the crus and leaves this same area during detumescence following erection. The stimulation that causes this reflex dilation of the deep artery of the penis also causes relaxation of the retractor penis muscles which hold the penis in the preputial cavity. As the retractor penis muscles relax, the sigmoid flexure relaxes and the mildly engorged penis protrudes from the sheath. With continued sexual stimulation the ischiocavernosus muscles
(ICM) begin rhythmic contraction which raises blood pressure from the normal resting state of 15 mmHg within the CCP. Peak pressure within the CCP may be greater than 14,000 mm Hg. This rapid increase in blood pressure within the CCP causes complete penile extension and erection. Following ejaculation the ICM relax, detumescence occurs as blood pressure within the CCP decreases and the penis is withdrawn back into the preputial cavity.

Erection may be induced in the bull with an ejaculator although the optimal method for evaluating erection is with observed test mating. Normal function of the penile nerves is essential for coitus and is most accurately assessed by observed test mating or by semen collection by artificial vagina.

**Observed test mating**

The normal bull approaches the cow from the side then moves to her hindquarters to smell the vulva and confirm that she is in estrus. The bulbospongiosus muscles begin rhythmic contractions which are visible as pulsations just ventral to the anus. As the retractor penis muscles relax the penis begins to protrude from the sheath and the bull prepares to mount. As he mounts the penis becomes engorged and the free portion should visibly extend from the sheath. When the bull fully mounts the glans penis makes two or three searching motions near the vulva then the penis makes forceful intromission, the bull ejaculates in one thrust then dismounts the cow.
Bulls with erectile dysfunction never achieve sufficient erection pressure to complete coitus. Bulls with nerve dysfunction mount the cow but the penile searching motions near the vulva are not evident and the bull fails to make intromission. Usually the penis is placed along the cow’s hip or below the vulva in the escutcheon area above the cow’s udder.

Miscellaneous Juvenile Penile and Preputial Conditions that May Prevent Intromission:

Penile papillomas - Warts caused by bovine papilloma virus occasionally develop on the body skin of young bulls which are reared together. The virus probably gains entrance into the skin of the penis and prepuce during abrasion of the skin during homosexual activity among young bulls. The growths are typically near the glans penis and do not usually recur after surgical removal.

Penile hair rings - Encircling rings of body hair also occasionally develop following homosexual riding by young bulls as body hair of the bull being ridden accumulates on the penis of the more aggressive bull. In extreme cases this encircling ring of hair may restrict blood flow to the distal penis.

Both penile papilloma and penile hair rings are usually found when young bulls are presented for breeding soundness examinations although blood may be noticed on the preputial hairs of affected bulls or on the vulva of females following breeding.

Persistent Frenulum - Delayed preputial-penile separation- Prior to puberty the penis
of the bull calf cannot be extended due to lack of a sigmoid flexure and the skin of the penis is attached to the skin of the prepuce in an interdigitating fashion. As androgen production shifts from androstenedione to testosterone the attachment of the penis and prepuce begins and should be complete between 8 and 11 months of age. Young bulls are sometimes presented with an incomplete separation at 12 - 14 months of age. In these bulls separation can be completed by pulling the prepuce back from the free portion of the penis. These tissues should separate easily and hemorrhage is seldom a problem. The penile frenulum is a thin band of connective tissue on the ventral midline of the free portion of the penis which adjoins the prepuce. Normally the frenulum ruptures during penile separation from the prepuce. When the frenulum does not rupture, the penis extends but the frenulum causes ventral bending of the distal penis during extension. Surgical repair is relatively simple but the owner should be advised that this condition is considered to be heritable.

**Erection Failure Due to Corpus Cavernosal Shunts (Impotential erigendi)**

**Congenital Vascular Shunts** - Occasionally young bulls will be presented for failure to achieve intromission due to congenital corpus cavernosal vascular shunts. These bulls usually appear normal on physical examination but fail to achieve adequate intracorporeal pressure for erection. When observed during test mating or with an erection induced by electroejaculation the free portion of the penis becomes noticeably bluish during attempted erection. The discoloration is due to blood from a relatively porous tunica albuginea of the penis exiting the corpus cavernosum penis and being removed by subcutaneous capillaries and veins. Typically the shunts are multiple and not considered to be repairable.
**Acquired Vascular Shunts** - Bulls may develop vascular shunts following trauma that penetrates the tunica albuginea of the penis. In the author’s experience this is a very uncommon cause of erection failure. However, as the penis heals following penile hematoma vascular shunts between the corpus cavernosum penis (CCP) and the peripenile vasculature may develop which prevents the CCP from being a closed system. Consequently the bull cannot achieve adequate blood pressure for erection. Affected bulls typically display normal libido and penile engorgement but do not develop adequate intracorporeal blood pressure to achieve intromission.

Contrast cavernosography may confirm vascular defects in the penis. Contrast cavernosography is best accomplished with the bull restrained on a table in lateral recumbency. Manually extend the penis and place a towel clamp under the dorsal apical ligament approximately 5 cm from the distal end of the penis to aid in manipulation of the penis during the procedure. Place a length of umbilical tape through the rings of the towel clamp to allow complete removal of the hands from the radiographic field during the procedure. Place a double strand of heavy suture through the skin of the sheath, between the retractor penis muscles and the penis, and through the skin on the opposite side of the sheath. This suture will serve to retract the penis away from the abdominal wall to enhance visualization of the sigmoid flexure of the penis.

Apply traction to the towel clamp to extend the penis and insert a 16-gauge needle at a 45° angle proximally through the skin and tunica albuginea and into the CCP. Place the needle on the dorsum of the penis near the towel clamp. To ascertain correct placement of the needle
inject 10 ml sterile saline which should flow into the CCP with ease. Attach a sterile extension set to the needle for ease of injection and to position the hands away from the radiographic field during injection of the contrast media. After placing a radiographic cassette under the penis inject 15 ml of water-soluble radiographic contrast media (Renograffin 76, Squibb Diagnostic, New Brunswick, NJ) and expose the film. Slowly inject an additional 15 to 30 ml of media as the radiographic series is performed. By using 17-inch-long cassettes the entire penis up to the sigmoid flexure may be radiographed with two or three exposures. Ideally all radiographic exposures should be completed within 60 seconds.

There are no vascular communications from the CCP to peripenile vasculature in the normal penis, and there should be no contrast media outside the CCP. A vascular shunt is identifiable as contrast media exiting the CCP.

**Inability to Extend the Penis (Phimosis)**

**Acquired preputial conditions** - Healed preputial laceration may lead to preputial stenosis and affected bulls exhibit phimosis, the inability to extend the penis. Preputial lacerations are more common in *Bos indicus* breeds and their crosses than in *Bos taurus* breeds. *Bos indicus* bulls usually prolapse the injured prepuce and preputial injuries in *Bos taurus* usually do not lead to prolapse. However, *Bos taurus* bulls are much more likely to develop preputial stenosis with the resultant inability to extend the penis.

Perhaps the most critical factors for determining the likelihood of returning to breeding
soundness for a bull with preputial laceration are the extent of the damage to the peripenile elastic tissue and the length of preputial skin that is lacerated.

*Bos indicus* with preputial stenosis may require circumcision in order to restore breeding soundness. *Bos taurus* bulls usually do not have sufficient preputial length to allow circumcision. These bulls may require preputial scar revision in order to restore breeding soundness. In each case the bull’s value should be reviewed in order to determine if surgical intervention is economically justified.

**Penile Hematoma** - Bulls with prior hematoma of the penis may not be able to complete coitus due to complications from the previous injury. Abscessation of the hematoma with subsequent scar tissue formation may prevent adequate penile extension. These bulls are usually not able to be returned to breeding soundness.

**Inability to Achieve Intromission due to Neuropathy**

Neuropathy of the dorsal nerves of the penis is not a common cause of inability to breed. However, trauma to the penis such as during preputial laceration or penile hematoma may result in nerve injury.

During penile hematoma injury the tunica albuginea ruptures on the dorsum of the distal bend of the sigmoid flexure. Peripenile elastic tissues and perhaps dorsal penile nerves may be
damaged by the jetting of blood under pressure from the CCP at the time of rupture. The paired dorsal nerves of the penis lie immediately along the tunica albuginea of the penis adjacent to the dorsal arteries and veins. Although numerous tests have been advocated to assess function of the dorsal nerves of the penis, observed test mating remains the method of choice for evaluating nerve function. Bulls with loss of penile innervation usually achieve erection but fail to make searching motions with the glans penis and fail to make intromission. Typically these bulls place the erect penis beside the tailhead on the cow’s hip or below the vulva against the escutcheon or udder.

Another method of assessing dorsal nerve dorsal penile nerve function is to place a properly prepared bovine artificial vagina (AV) over the penis of a bull that has been adequately stimulated and allowed to mount a female in estrus. Bulls with normal nerve function will readily ejaculate into the AV.

Measurement of nerve conduction velocity of the dorsal penile nerves provides a quantitative test of nerve function. This procedure requires sophisticated instrumentation seldom found outside veterinary teaching hospitals.

References

Field Diagnosis and Management of Disorders of the Testes and Seminal Vesicles in bulls  
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Introduction  

Seminal vesiculitis (vesicular adenitis) is inflammation of the vesicular glands of bulls. Typically there are minimal to no overt clinical signs other than alteration of the ejaculate which contains many polymorphonuclear leukocytes, decreased sperm motility, and varying degrees of sperm abnormalities.  

Several theories postulate that asynchrony in the ejaculatory process could cause reflux of semen and urine into the seminal vesicle. One study showed that up to 40% of bulls with vesiculitis had congenital abnormalities of the ducts. Numerous infectious agents have been associated with vesiculitis in bulls and some bulls exhibit negative bacterial and viral cultures but have moderate to severe histological changes. Various authors report ascending infections from the urethra, descending infections from other urogenital organs, and hematogenous infections.  

Bulls with vesiculitis fall into 2 general categories. The condition is considered quite common in yearling bulls housed together on high concentrate diets. The problem is usually only detected when the bulls are examined for breeding soundness and found to have enlarged seminal vesicles and white blood cells in the ejaculate. Although some practitioners advocate antimicrobial therapy, bulls less than 2 years old generally recover without treatment.  

Vesiculitis is not common in bulls greater than 2 years of age. Bulls in this category rarely recover from seminal vesiculitis despite aggressive therapy. Frequently the glands are quite enlarged and purulent material may be expressed from the glands by rectal message. Culture of the exudate usually
reveals *Arcanobacter pyogenes*. Although several antibiotics appear to achieve therapeutic levels in the tissues, complete clearance of the infection is rarely successful. Several surgical approaches have been advocated to remove the infected glands. The surgery is technically difficult due to the proximity of the duct of the seminal vesicle and ampullae at their junction with the urethra.

**Treatment Protocol**

We have experimentally ablated the seminal vesicles as well as treated several bulls with clinical vesiculitis via percutaneous infusion of the glands with 4% formalin solution. Restrain the bull in a chute and achieve epidural anesthesia and administer flunixin meglumine intravenously. Prepare the perianal area for aseptic surgery and introduce the gloved hand into the rectum to isolate and stabilize the vesicular gland. Introduce an 18 ga x 28 cm spinal needle through the skin lateroventral to the anus and advance the needle into the vesicular gland. Verify placement of the needle within the gland by injecting a small quantity of saline then infuse the gland with 4% formalin. Others have utilized tilmicosin for this treatment. We have also successfully treated one bull with septic prostatitis with this technique. That bull was subsequently classified as a satisfactory potential breeder according to the standards of the Society for Theriogenology and has confirmed pregnancies in a group of females.

**Problems with the Scrotum and Testicles**

The bull scrotum is a dependent appendage of the skin which protects the testicles and helps regulate testicular temperature. Testicular thermoregulation is a complex process which includes contraction of the tunica dartos and cremaster muscles to alter scrotal surface area and distance of the
testicles from the body. The scrotum is one of the few places in the bovine where sweat glands are found. Blood temperature is regulated by countercurrent heat exchange between the testicular artery and vein in the pampiniform plexus. Working together these mechanisms maintain testicular temperature 4 - 6°C below core body temperature which is optimal for normal semen production.

**Diagnosis of Testicular Disease or Injury**

Testicular degeneration is the partial or complete failure of normal sperm production by the testes. Immature cells such as primary spermatocytes and germinal epithelial cells are more sensitive to insult than spermatozoa. Arguably the most common cause of testicular degeneration is elevated testicular temperature which may be due to scrotal dermatitis, excessive scrotal fat, or insulting masses within the scrotum such as hydrocele, hematoccele, edema, and periorchitis. Additionally, high ambient temperature and elevated local temperature due to febrile conditions or scrotal inflammation may cause testicular degeneration.

**Physical Examination of the Scrotum and Testicles** - Carefully examine the scrotum for dermatitis, edema, scar tissue and symmetry. Palpate the testicles for relative size, firmness, symmetry, evidence of pain or swelling, presence of fluid in the vaginal cavity, and the ability of the testicles to move freely within the vaginal cavity. There should be no more than 10% difference in the size of the testes and normal testicular tone approximates that of liver. Scrotal circumference is heritable and highly correlated with daily sperm output, sperm reserves, serving capacity and age of puberty of the bull’s offspring. Measure the scrotal circumference with a non-elastic tape at the widest circumference of the scrotum. This measurement can be compared against normal values which are readily available in tables.
for scrotal circumference in different age bulls but the minimum scrotal circumference recommendations from the Society for Theriogenology bull breeding soundness evaluation serve as an excellent reference.

<table>
<thead>
<tr>
<th>1992 SFT Criteria for Bull Breeding Soundness</th>
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<tbody>
<tr>
<td>Scrotal Circumference (minimum)</td>
</tr>
<tr>
<td>30 cm at ≤ 15 mo</td>
</tr>
<tr>
<td>31 cm at &gt;15 ≤ 18 mo</td>
</tr>
<tr>
<td>32 cm at &gt; 18 ≤ 21 mo</td>
</tr>
<tr>
<td>33 cm at &gt; 21 ≤ 24 mo</td>
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<tr>
<td>34 cm at &gt; 24 mo</td>
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Ultrasound of the Testicles - Confirmation of diagnosis of scrotal or testicular disease may be aided by B-mode real-time ultrasound using a 5-MHz probe. Normal testicles are homogenous and moderately echogenic. The mediastinum testis is a readily indentifiable hyperechoic area in the center of the testicle when viewed in the transverse plane or a hyperechoic line when viewed in the sagittal plane. The head, body and tail of the epididymis are less echogenic than the testicle and are readily identified as they course along the testicle. Thickness of the scrotal skin and vaginal tunics and the presence of fluid within the vaginal cavity are readily determined.

Thermography of the Scrotum - The testicular temperature must be below body temperature for normal spermatogenesis in bulls. Infrared thermography provides a non-invasive, noncontact imaging technique to determine normal and abnormal thermal patterns in bulls and other animals. Thermography utilizes sensitive infrared imaging to produce a color photograph that portrays variations in surface temperature. In mammals the skin surface temperature reflects the temperatures of tissues immediately beneath the skin. The normal thermogram of the scrotum in all species is a left and right symmetric pattern with a constant decrease in temperature gradient from the base to the apex. In bulls the temperature gradient of 4 to 6°C from base to apex is considered normal. A gradual decrease from base to apex with concentric color bands is consistent with normal function of the vascular countercurrent heat-
exchange mechanism of the testes. Either excessively cool or excessively warm areas as evidenced by thermographic color are consistent with testicular disease or injury.

**Semen Evaluation** - It is beyond the scope of this manuscript to thoroughly discuss collection and evaluation of bull semen. However, semen should be routinely be evaluated when examining bulls for reproductive efficiency. Bull’s with less than 70% morphologically normal sperm of which less than 30% are progressively motile are considered to be subfertile and deserve further examination to determine the cause of subfertility.

**Surgical Repair of Testicular Problems**

The only conditions of bull scrotum readily amenable to surgical repair are those that involve only one testicle. Bulls with unilateral problems such as testicular rupture, hydrocoele, or severe periorchitis may return to breeding soundness following removal of the affected testicle.

Restrain the bull in lateral recumbency and with anesthesia or heavy sedation and local anesthesia of the scrotum and spermatic cord clip and prep the scrotum for aseptic surgery. Make a 15-cm vertical skin incision from near the base toward the apex leaving the parietal vaginal tunic. Separate the testicle within its parietal tunic from the scrotal fascia by blunt dissection. Make a 12-cm incision through the parietal tunic beginning proximally and ending at the cranial pole of the testicle then exteriorize the testicle through the incision and expose the spermatic cord.

Eight cm proximal to the pampiniform plexus isolate and doubly ligate the spermatic artery, vein and ductus deferens with #O chromic gut then transect between the two ligatures. Transect the vaginal
tunic then ligate and transect the external cremaster muscle distal to the stump of the spermatic cord. Close the tunic with an inverting pattern such as a Connell or Parker-Kerr using #0 chromic gut.

Excise excessive scrotal skin to minimize dead space at the surgical site and close the tunica dartos in a simple continuous pattern with #0 chromic gut. Close the skin with a continuous interlocking pattern of 0.4-mm synthetic suture.

Administer procaine penicillin G (22,000 IU/kg IM once daily for 5 days) or oxytetracycline (9 mg/# IM) postoperatively and observe the bull daily for swelling or drainage from the surgical site. Remove sutures 10 days postoperatively and the bull should be ready to return to service when the spermiogram returns to normal.

References