Reproductive Management

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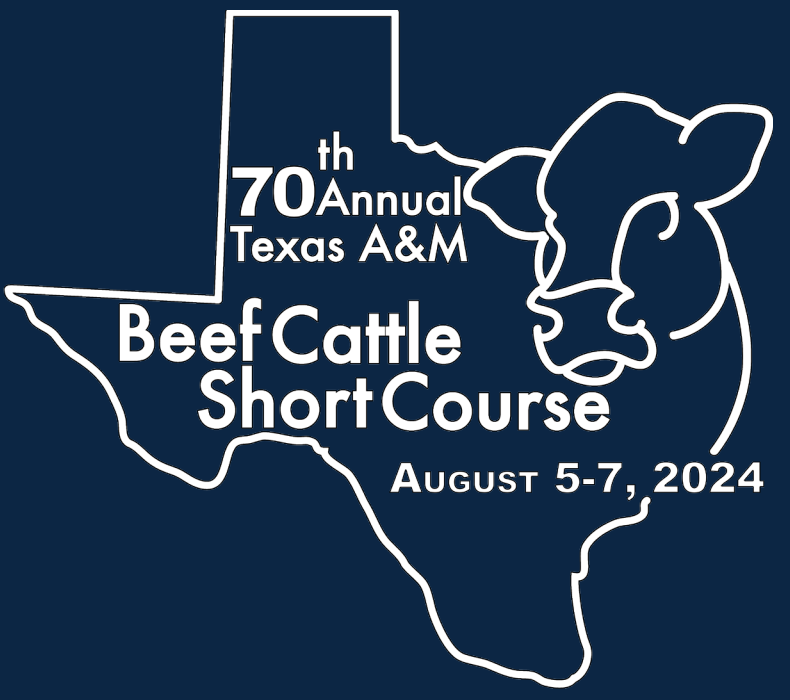

Reproductive Management

CAPITAL FARM CREDIT

What Makes Bulls Work (or not) in the Pasture?

Bruce B. Carpenter, PhD
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Introduction

Under natural service conditions, for a sire to be a genetic asset he must first be able to find, travel to, successfully service, and successfully impregnate estrus females. For example, it is not unreasonable to expect an extremely fertile bull to sire 60 or more calves in a short breeding season, whereas a truly infertile bull might sire none - even in a long breeding season. In truth, the fertility of most bulls probably falls somewhere in the middle of these extremes. Fertile bulls are of greater economic value, not only because of the number of calves they can sire, but also because they tend to settle cows earlier in the breeding season, resulting in older and heavier calves at weaning. Properly managing any given bull from weaning through maturity will maximize his inherent fertility and boost his contribution to overall herd productivity.

The following summarizes factors known to affect fertility in bulls. Some of these are inherent, some may be acquired, and some will be determined by management.

- Proper nutrition and herd health
- Structural correctness - eyes, feet, legs, skeleton
- Properly functioning genitalia
- Adequate scrotal circumference
- Semen quality
- Proper birth weight for calving ease
- Age at puberty
- Libido and Serving Capacity
- Social interactions
- Inherent prolificacy (all else equal, some bulls just sire more calves than some others)

✓Breeding Soundness Examinations are useful in estimating a bull's fertility since many (but not all) of these factors are evaluated.

Disease

Diseases affecting both young and mature bulls are essentially the same as those of breeding females. Detailed discussions of these diseases will be presented by later speakers.

Nutrition

Adequate nutrition allows young bulls to more completely express genetic potential for growth, which predicts potential performance of eventual offspring. More importantly proper nutrition allows puberty to begin on time, allowing moderate breeding use by 15 to 17 months of age. Severe undernourishment can cause irreversible testicular damage in young bulls and decreased sperm production in older bulls. Conversely, getting bulls excessively fat can reduce libido, cause structural unsoundness and impair ability to travel.

In performance tests it is still argued as to whether weanling bulls should be fed for maximum gain on a full-feed test, or for moderate gain on forage. The former approach sometimes results in excess fatness, which can temporarily reduce breeding performance and sperm quality. The moderate gain approach may avoid these problems but precludes the chance

for maximum gain which offers more opportunity to observe inherent genetic differences among bulls for growth. Breeders should refer to their association regarding specific test conditions.

Cottonseed products have been used successfully for years as a concentrated source of protein in cattle rations. During the 1980s, concern arose over the use of cottonseed products in the diet of young bulls. The naturally occurring gossypol contained in the cottonseed can temporarily reduce sperm quality in young bulls when fed at excessive levels for long periods of time. However, severity of these problems varies because of the toxicity effects of gossypol are influenced by cotton plant variety, cotton oil extraction procedures, diet content of cottonseed products and length of feeding period. Consequently, some degree of caution is warranted, but cottonseed products are completely save in the diet of young bulls if these guidelines are followed. These levels fall within the range of what typically has been fed over the years with no negative effects on reproductive performance.

■ Whole cottonseed should be limited to 10 percent or less of a young bull's total diet (15 to 20% for mature bulls).

■ Solvent-extracted cottonseed meal (a process used by 95% of TX and OK mills) should be limited to 5 percent or less of the total diet.

■ Mechanically extracted cottonseed meal (used by less than 6% of TX and OK mills) can be fed at a level of up to 15 percent of the total diet.

Assessing Fertility

Whether in young or mature bulls, a fertility assessment is required before breeding performance can be predicted. For a bull to impregnate females, the requirements are more complicated than expected. Bulls in good overall health must still have enough libido to pursue, mount and serve an estrus female. This involves travel over short or long distances in varying terrain, requiring sound eyes, feet, and legs. Copulation requires functional genitalia free of abnormalities. Finally, quality sperm must be deposited.

The Breeding Soundness Examination (BSE) should be the minimum test performed annually on all breeding-age bulls. Examinations should be conducted about 60 days before the breeding season starts. A BSE is probably still the most effective means of estimating fertility on a practical level. The conventional BSE does not evaluate every factor which is known to, or suspected of, influencing fertility; nor does it guarantee fertility. It merely provides a fair estimate of a given bull's fertility potential. It can provide a good assessment of what actual semen quality and production was like at a single point in time. The procedure is most often performed by a veterinarian who is familiar with semen evaluation techniques. However, any herdsman will probably visually evaluate some of the components of a BSE whenever he sees his bulls. The first component of a BSE is an evaluation for structural correctness.

Structural Correctness. This includes a general evaluation of the skeleton, particularly the feet and legs. Can the bull walk and get around okay today? The mouth and teeth are usually evaluated, as are the eyes. Good eyes are especially important for bulls. Research indicates that the primary stimulus for a bull to seek estrus females is his ability to first visually locate groups of sexually active females (i.e. females that are being mounted by others in the herd).

Testis, Genitalia and Scrotal Circumference are also evaluated. Both testis will be observed for normal size and decention into the scrotum. They will be palpated for texture. The penis will be observed for physical abnormalities and at some point the sheath, prepuce and

accessory glands will be evaluated. Scrotal circumference will also be measured. Bulls with larger testicles produce more sperm cells and in addition to enhanced sperm production, research has also shown that bulls exhibiting larger scrotal circumferences, reach puberty sooner, and also sire daughters that reach puberty at earlier ages. Scrotal circumference is moderately heritable and therefore progress can be made through selection. Puberty begins later in straight bred and crossbred Brahman breeds than in British and Continental breeds. Table 1 describes minimum scrotal circumference in a Breeding Soundness Exam.

Table 1. Current Recommendations Minimum SC in Bulls

Age (months)	Scrotal circumference
≤ 15	30 cm
≥ 15–18	31 cm
≥ 18–21	32 cm
≥ 21–24	33 cm
≥ 24	34 cm

Society for Theriogenology, 2018

Semen Evaluation will usually consist of microscopic examination of spermatozoa for motility, concentration and normality. There are also new procedures which utilize test kits containing reducible dyes (color change) to test sperm motility and concentration. Also, computerized digital photographic lab systems have been developed to evaluate sperm motility.

Following the BSE the bull will either be classified as satisfactory or unsatisfactory as a potential breeder. Any bull classified as unsatisfactory should probably be re-tested before he is culled.

Libido and Serving Capacity. Neither libido nor serving capacity is typically assessed during a conventional BSE. Libido has been defined as sexual aggressiveness whereas, serving capacity has been defined as copulatory proficiency. It is possible for bulls to possess good libido but still not be able to properly service a female. Both libido and serving capacity are distinct elements of reproductive function and unfortunately, their correlation to BSE parameters appears to be weak or nonexistent. In other words, bulls may possess good semen but may still lack the ability or desire to service females.

It is possible to objectively measure libido and serving capacity in bulls. A variety of methods have been evaluated. Essentially, groups of bulls are given the opportunity to service females in either of two ways: 1) restrained females, or 2) non-restrained estrus females. The number of attempted and completed services during a 20 to 30 minute period is recorded. Each method has certain advantages and disadvantages. Use of non-restrained females requires estrous synchronization which in turn, requires relatively large numbers of non pregnant but cycling females. Response to synchronization treatment is also a consideration. Use of females restrained in specially designed service crates requires fewer animals, but may not always sufficiently stimulate serving activity in Bos indicus influenced breeds. As stated, serving capacity appears to be a measurable component of bull fertility. However, procedures for its measurement are not

always practical in many commercial ranching situations. Simple observation of mating activity in the pasture is better than nothing, but it has shown a generally poor relationship to serving capacity results obtained with standardized testing procedures.

There are probably several factors at work in determining what a bull's serving capacity is. Serving capacity appears to be a moderately heritable trait that is somewhat genetically determined. Serving capacity can vary between individuals and possibly even sire-lines. Libido is dependent, to a degree, upon the male hormone, testosterone, which is produced by the testis. However, it appears that once relatively low "threshold" concentrations of circulating testosterone are achieved, that concentrations beyond this level do not impart higher libido. In other words, high testosterone is not necessarily related to high libido. Similarly, masculine characteristics such as crest of neck or forehead hair whorl are not necessarily predictive of higher libido.

Age, breed and prior sexual experience may all interact to influence how a bull displays his inherent serving capacity during testing.

Bull performance in serving capacity tests can be used to predict fertility under natural mating situations. Higher pregnancy rates and/or improved conception patterns have been observed for higher serving capacity bulls evaluated in pasture mating studies. In two trials, high-serving-capacity bulls increased pounds of calf weaned per cow by an additional 60-98 pounds compared to that of low-serving-capacity bulls.

Social Ranking. In multiple-sire pastures, socially dominant bulls may obtain access to more females. This is probably acceptable if that bull is also of high fertility. However, problems might arise if a bull were socially dominant, yet still lacked reproductive function. For example, a socially dominant bull with poor semen quality would likely not sire many calves. Social ranking does not appear to be related to either semen quality, libido, or serving capacity.

Social dominance orders within a mix of bulls may be subtle and, once established, are usually maintained without aggressive fighting. Fighting among bulls may simply indicate that the social dominance order has yet to become established. Age can be a factor in social dominance. For managers interested in using younger bulls, manipulating the age mix, so that yearlings and two-year-olds do not compete with older bulls may be the best way to minimize lost breeding opportunities for younger bulls. As one might expect, large physical body size and presence of horns have been shown to impart higher dominance ranking in most (but not all) bulls.

Inherent Prolificacy. With the advent of DNA parentage testing technology, researchers have documented wide variation in the number of calves sired by individual bulls within multiple-sire breeding pastures. Researchers evaluated data from 3 northern CA ranches, over 3 years and 15 calf-crops, with both spring or fall breeding seasons. 5000 calves were identified by sire with DNA testing. The number of bulls per pasture ranged from 2 to 9. But bull:cow ratio was constant at 1:25. All bulls passed a BSE every year. Young bulls were not placed with older bulls.

Average number of calves sired by bull was 19 and was remarkably similar by ranch, year, and season. However, the number of calves sired ranged greatly: from a high of 64 to a low of zero (4.4% of all bulls sired zero calves in any given breeding season). Figure 1 shows that 40% of the pastures had at least one bull in the battery that sired at least 50 calves, and conversely, 40% of the pastures had at least one bull that sired one or fewer calves.

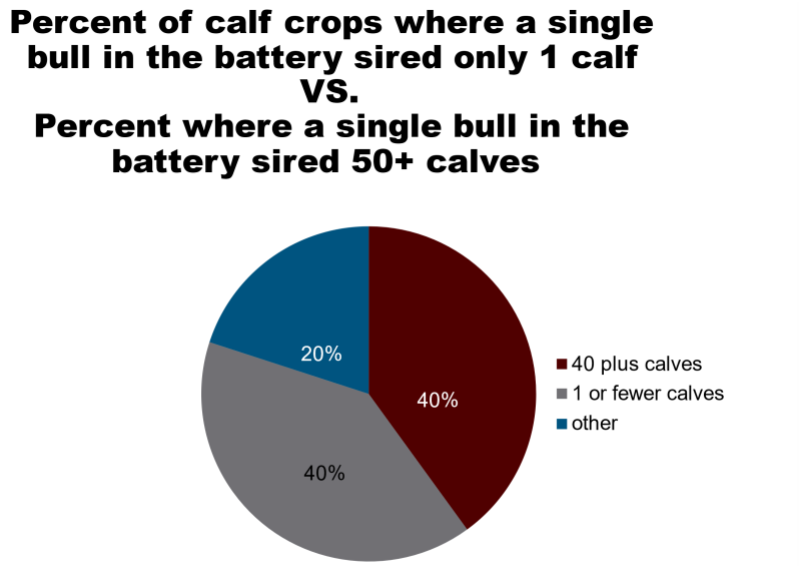

Figure 1. Drake et al. 2014

Bull prolificacy peaked at about 5-years-of-age. However, one outlier bull was still passing a BSE and siring calves: where at age 9 he sired 50 calves, at age 10, 22 calves and at age 11, he sired 20 calves.

Bulls were grouped as 'high', 'medium' and 'low' prolificacy. Calving patterns showed that medium and low bulls' calves were born evenly throughout the calving season. Whereas about twice as many calves from high prolificacy bulls were born in the first half of the breeding season – which also meant higher weaning weights from those bulls.

Van Eenennaam et al. evaluated 16 high EPD carcass merit bulls over 5 calf crops. Carcass from those calves received an average premium of $721 and was similar for all bulls' calves. However, the number of calves marketed by bull ranged from 7 to 77. Obviously, the bull who sired the most calves made the most on carcass premiums: $55,889 on 77 calves vs. $4,881 on 7 calves.

Costs and Potential Uses of DNA Paternity Testing. Currently it costs about $15 per calf. Other costs might include data collection and management. Possible uses have been suggested:

- For all new bulls, obtain a hair sample but do not process
- If a small number of calves are very large and cause calving problems use DNA paternity testing to find if a single sire is the problem
- Determine low prolificacy young bulls and cull to increase fertility of replacements and to lower bull costs.
- Assess prolificacy so all breeding groups have HP bulls, and raise cow to bull ratio

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ANSC-PU-101
September 1998

BREEDING SOUNDNESS OF BULLS

L.R. Sprott[1], T.A. Thrift[2], and B.B. Carpenter[3]

The importance of the bull in a cattle breeding program often is underestimated. A cow is responsible for half the genetic material in only one calf each year, while the bull is responsible for half the genetic material in 20 to 50 calves. The bull's ability to locate cows in estrus and breed them is clearly vital to a successful breeding program.

Bulls differ in physical appearance, fertility and sex drive (libido). In the past, when a cow failed to become pregnant it was assumed that she was at fault. Occasionally, that is true. However, a clear understanding of the male reproductive system and the differences between reproductive capabilities of bulls indicates that the cow is not always at fault.

REPRODUCTIVE SYSTEM

One of the major organs of the bull's reproductive system, the testis (or testicle), is made up of two tissues that perform different functions. The seminiferous tubules produce sperm, while the Leydig cells (interstitial tissue) produce testosterone. The testes should be free and not adhering to the inside of the scrotum. A minor twist in the scrotum resulting in a slightly sideways suspension of the testicles may not affect reproductive performance but is abnormal in conformation and visually unpleasing. A major twist may indicate structural defect and reduced fertility.

The scrotum supports and encloses the testes. Its main function is to regulate testicular temperature. It does so through perspiration and by muscular contraction that raises the testicles in cold weather and relaxation that lowers them during warm weather.

Inside the scrotum (Fig. 1) and adjacent to each testicle is the epididymis, a 10- to 12-foot long, tightly coiled tube made up of three sections (head, body and tail). The functions of the epididymis are concentration (from 100 million/cc to 4 billion/cc), storage, maturation and transportation of sperm cells. Immature sperm cells are immobile when they enter the epididymis, but become mobile after maturation. Their ability to fertilize an egg requires a period of retention in the female reproductive tract after mating, and exposure to certain compounds contained there.

The vas deferens extend from the epididymis to the ampullae. They aid in transport of sperm cells. Prior to ejaculation, sperm cells are pooled in the ampullae. The seminal vesicles and prostate gland contribute volume to the ejaculate by secreting fluid that contains substrates, buffers, inorganic ions (sodium, chlorine, calcium, etc.) and proteins. These proteins (known as fertility associated antigens) are particularly important since they bind to certain compounds in the female tract that increase the chances of fertilization. At ejaculation, the semen is transported via the urethra and through the penis.

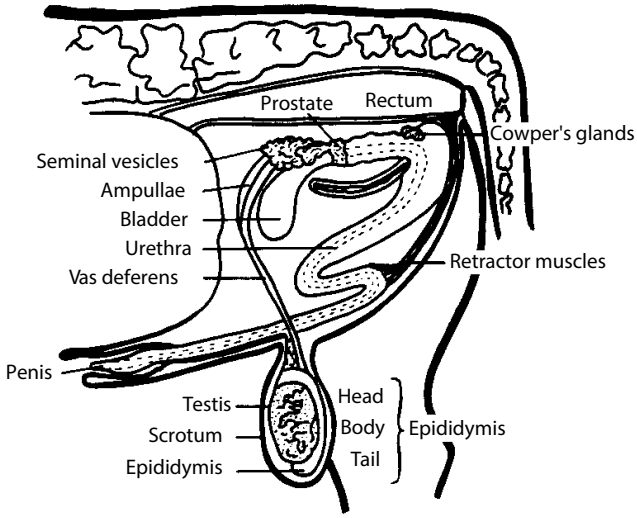

Figure 1. The reproductive tract of the bull.

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BREEDING SOUNDNESS EVALUATION

Bulls should be evaluated for breeding soundness 30 to 60 days before the start of breeding to allow sufficient time to replace questionable bulls. Bulls should also be evaluated at the end of breeding to determine if their fertility decreased. This second evaluation may explain a low calf crop percentage.

A breeding soundness evaluation (BSE) is administered by a veterinarian and includes a physical examination (feet, legs, eyes, teeth, flesh cover, scrotal size and shape), an internal and external examination of the reproductive tract, and semen evaluation for sperm cell motility and normality. Libido is not included in a BSE; it must be measured through visual observation during mating activity.

Physical Examination

Part of the physical examination involves the overall appearance of the bull. Flesh cover (body condition) is one factor to evaluate. Body condition can vary by breed, length of the breeding season, grazing and supplemental feeding conditions, number of cows the bull is expected to service, and distance required to travel during breeding. A thin bull may not have the stamina needed to service many cows in a short period on extensive range conditions (large acreage). An overly fat bull may lack vigor and not be able to breed up to his potential. Excessively thin bulls and fat bulls usually have low quality sperm. Ideally, bulls should have enough fat cover at the start of breeding so their ribs appear smooth across the animal's sides.

Sound feet and legs are very important. Bulls with structural unsoundness such as sickle hocks, post legs, and bent or knock knees may develop soreness. The result is the inability to travel and mount for mating. Long hooves and corns between the hooves result in similar problems.

Eyes should be clear and injury free. The teeth are checked for excess wear or loss. The general health of the bull is critical since sick, aged and injured bulls are less likely to mate and usually have lower semen quality.

Examination of the Reproductive Tract

An internal (rectal exam) and external examination should be conducted. The rectal exam is to detect any abnormalities in the seminal vesicles, prostate, ampullae and the internal inguinal rings. Rarely are there any problems with the prostate, but an infection can occur in the seminal vesicles leading to a condition called seminal vesiculitis. This is not an unusual condition in bulls and is characterized by enlargement of the seminal vesicles. Rarely are there complications with the ampullae, but the inguinal rings are examined for indications of hernia. Major herniation can also be observed externally. The latter is characterized by abnormal enlargement of the scrotum and manual palpation of intestinal loops within the scrotum.

The external examination of the reproductive tract includes manual palpation of the testes, spermatic cords and epididymis. The testes should feel firm, while the upper portion of the epididymis should feel soft and free of any lumps or enlargements.

Degeneration of the testes may occur at any time and can be caused by prolonged hot weather with high humidity, poor blood circulation, age, trauma, stress, bacterial diseases of the testes and genetic susceptibility. A general sign of degeneration is a decrease in testicular size. Maintaining records of annual BSE results for each bull will help detect changes in testicular size.

Scrotal circumference is an important measure since it is directly related to the total mass of sperm producing tissue, sperm cell normality, and the onset of puberty in the bull and his female offspring. Bulls with large circumference will produce more sperm with higher normality. They also reach sexual maturity sooner, as do their daughters. Table 1 shows average scrotal circumference of various beef breeds.

Examination of the penis and prepuce will detect inflammation, prepucial adhesions, warts, abscesses and penile deviations. The erect penis should be parallel to the bull's body.

Semen Evaluation

During a BSE, bulls will be electroejaculated and their semen should be microscopically evaluated for sperm cell motility and normality. Unless there is an obvious lack of sperm cells in the sample, cell concentration in the sample may not be very informative, as some bulls do not always respond well to electrical stimulus. Even then, it is wise to collect semen a second time to confirm if concentration is low. Sperm cell motility and normality are not necessarily affected by electroejaculation and can easily be assessed during examination. They are the most important characteristics because a high number of moving, normal sperm cells are required for fertilization of an egg.

The criteria for scoring on a BSE are shown in Table 2. Any bull meeting all minimum standards for the physical exam, scrotal size (varies by age and breed), and semen quality will be classed as a satisfactory potential breeder. Bulls that fail any minimum standard will be given a rating of "classification deferred." This rating

Table 1. Comparison by age of average scrotal circumference (cm) of beef breeds.								
Breed	Months							
	<14	14-17	18-20	21-23	24-26	27-30	31-36	>36
Angus	34.8	35.9	36.6	36.9	36.7	36.3	36.6	38.2
Charolais	32.6	35.4	34.5	34.9	34.6	36.2	37.1	38.1
Horned Hereford	33.0	32.2	34.1	36.2	33.4	33.8	35.2	34.0
Polled Hereford	34.8	34.2	34.9	34.9	34.8	35.0	35.6	36.4
Simmental	33.4	36.5	--	--	36.0	--	--	37.2
Limousin	30.6	31.7	32.0	33.9	--	--	--	35.5
Santa Gertrudis	34.0	35.3	35.5	36.7	36.5	36.4	38.3	40.5
Brahman	21.9	27.4	29.4	31.4	31.7	33.5	34.7	36.7

indicates that the bull will need another test to confirm status. Mature bulls should be retested after 6 weeks. Should they fail subsequent tests, mature bulls will be classed as unsatisfactory potential breeders.

Young bulls rated as classification deferred may not have reached sexual maturity and should be retested at monthly intervals until puberty is confirmed. It should be remembered that, even though accurate, a BSE is nothing more than a snapshot of a bull's breeding potential at that point in time. Since a bull's physical condition and sperm quality can change, a BSE should be done on all bulls annually prior to the start of breeding.

Libido and Ability to Mate

Libido is, of course, a precursor to the ability to mate, but some bulls (10 to 35 percent) cannot mate even though they have high libido. Injury, lameness, illness, and penile abnormalities may prevent bulls from accomplishing the act of mating. There is also evidence that libido and mating ability are genetically influenced.

Libido and the ability to mate are not measured during a BSE and can only be assessed by observing bulls in the presence of females. The number of mounts and services accomplished by the bull in a given period of time are recorded. Based on a scoring system, bulls are classed as having either high, moderate or low serving capacity. High serving capacity bulls are the most desirable because they settle more cows in fewer days than do moderate and low bulls. Whether formal tests for serving capacity are performed or not, producers are encouraged to observe their bulls during the breeding period to detect any bulls not performing their duties.

Table 2. Scoring criteria for a BSE.		
Minimum sperm motility - 30%		
Minimum sperm normality - 70%		
Minimum scrotal circumference (by age)		
	Age (months)	Circumference (cm)
	15 or younger	30
	16-18	31
	19-21	32
	22-24	33
	25 or older	34
Physical exam		
Must have adequate body condition and sound feet, legs and eyes.		
Must have no abnormalities in:		
	seminal vesicles ampullae prostate inguinal rings penis prepuce testicles spermatic cord epididymis scrotum (shape & content)	
Adapted from Society of Theriogenology (1992).		

Unfortunately, libido and serving capacity are not related to BSE results or visual estimates of masculinity (thickness of the neck, muscle definition, coarseness of hair). Testosterone levels in the blood are slightly related, but only to a minimum threshold. Bulls with testosterone levels beyond this threshold are not necessarily good breeders.

Nutrition

Nutrition is important during the development of a young bull's reproductive system. Improved levels of nutrition will hasten puberty and body development. Extremely high levels of nutrition may lower libido and magnify structural weakness.

Underfeeding for prolonged periods will delay puberty and cause irreversible testicular damage. If a mature bull is subjected to prolonged underfeeding, sperm quality and libido will decrease. Overfeeding of mature bulls may result in similar problems, but adjustments in feed levels may reverse the situation. Approximate nutrient requirements for growing and mature bulls are shown in Table 3.

Genetic Factors Affecting Fertility

The onset of puberty, libido and serving capacity are influenced by genetics. There are differences both between and within breeds. Recent work regarding the presence of fertility associated antigens in sperm (see "Reproduction System") also indicates a degree of genetic control.

Generally, *Bos taurus* breeds mature at an earlier age than *Bos indicus*. Crossbreeds of these two will reach puberty at some age between their parent breeds. Other research indicates that earlier maturity in any breed can be accomplished by selection for increased yearling scrotal circumference.

In summary, many producers work hard to manage their cows for high fertility. They may assume that the bulls will do their expected duties, but thorough fertility management also includes attention to the bulls.

Table 3. Approximate nutrient requirements for bulls.

Body weight	Gain	TDN	Total protein	Ca	P
600	2.5	73.5%	11.4%	.46%	.24%
700	2.5	73.5%	10.5%	.40%	.22%
800	2.0	67.5%	9.2%	.31%	.20%
900	1.5	63.0%	8.4%	.25%	.19%
1000	1.5	63.0%	8.1%	.24%	.19%
1100	1.5	61.0%	8.1%	.24%	.19%
1300	1.5	56.0%	7.6%	.22%	.19%
1500	1.5	56.0%	7.4%	.21%	.19%
1700	0	48.0%	6.8%	.21%	.21%
1900	0	48.0%	6.8%	.21%	.21%
2200	0	48.0%	6.8%	.22%	.22%

From National Research Council, 1984. Nutrient requirements of beef cattle.

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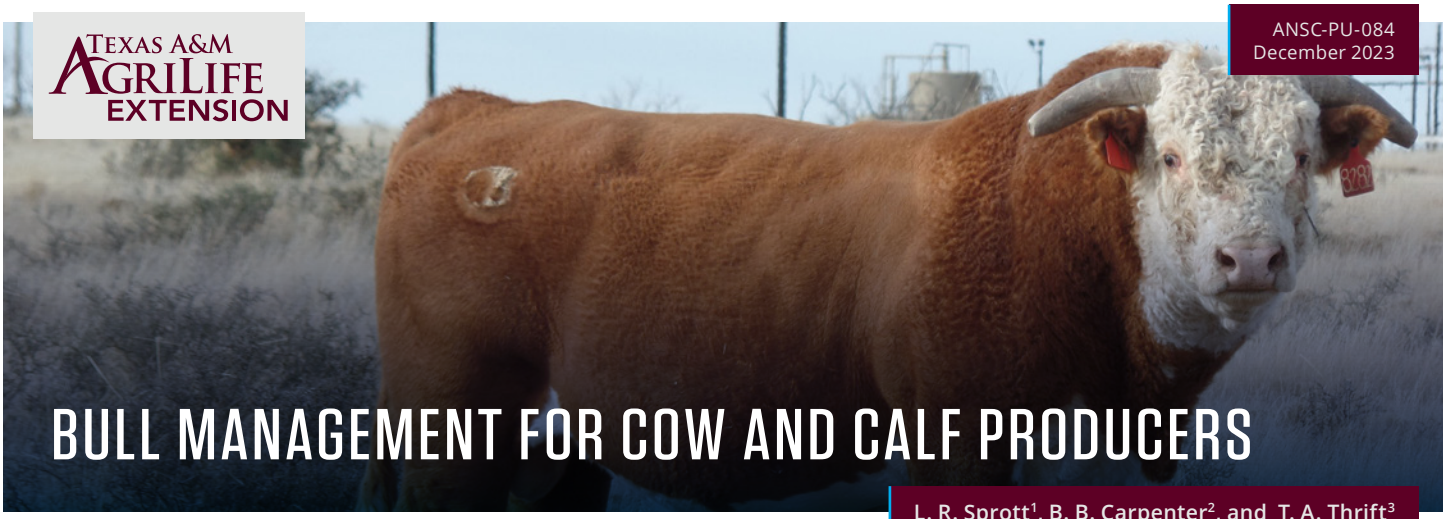

BULL MANAGEMENT FOR COW AND CALF PRODUCERS

L. R. Sprott[1], B. B. Carpenter[2], and T. A. Thrift[3]

It is often said that a bull contributes half of the production in a calf crop. This may be true for an average bull, but it probably exaggerates contributions from a poor-quality bull and dramatically underestimates those from a good bull. A good bull offers both high fertility and high genetic breeding value for one or more economically important characteristics, such as growth, calving ease, maternal value, and carcass quality.

Fertility in a bull is generally defined as the ability to impregnate females, which is certainly a minimum requirement, but a bull with high fertility is able to impregnate more than the expected number of cows in a short breeding season. Such a bull has greater economic value than one of lesser fertility.[1, 20] If the bull also has a desirable genetic background, it could contribute more than just half the production in a calf crop. Properly managing bulls from weaning through maturity will boost their contributions to herd productivity. When selecting bull calves at or before weaning, breeders must carefully consider future genetic goals for the herd and base their decisions on economically important characteristics. After bull calves are chosen, whether for retention as replacements or for eventual sale, their growth and well-being depends mainly on disease prevention and adequate nutrition.

DISEASE PREVENTION

Diseases affecting both young and mature bulls are essentially the same as those of breeding females. Do not assume that vaccinating one of these groups will also protect the other. Rather, vaccinate both males and females. Certain reproductive diseases (e.g., BVD and leptospirosis) can develop in the fetus while it is still in an infected female's uterus, resulting in offspring that become carriers of the disease. To prevent this carrier status of leptospirosis, vaccinate females at pre-breeding and again at pregnancy testing. Vaccinate bulls at least annually for all five serovars (i.e., 5-way lepto) of leptospirosis and for campylobacter (vibrio). In some cases, vaccinations may be needed twice a year. Occasionally, vaccinations for BVD and other viral diseases are recommended, but producers should consult their veterinarians for specific recommendations for diseases prevalent in their areas. Bovine trichomoniasis (trich) is a venereal disease caused by the protozoan (*Trichomoniasis foetus*). Because trich has no visible symptoms in bulls and few, if any, visible symptoms in cows and heifers, it is best to prevent exposure to the disease rather than try to control or eradicate it. The primary production and/or economic impact of trich is on cows because the disease causes infertility and abortions and often extends the breeding and calving season. Bulls become infected by breeding infected cows. The protozoa reside in the crypts or microscopic folds on the surface of the bull's penis and internal prepuce. The infected bull will show no symptoms. Laboratory tests can determine whether a bull is infected. Only a certified, accredited veterinarian may collect samples from the bull's penis and internal prepuce and submit them to a certified laboratory for analysis. There is a vaccine for trich, but it has significant limitations and should be used under direction from a veterinarian.

Buy bulls only from herds in which adequate disease-prevention measures are practiced and administer booster vaccinations upon arrival at their destination. A 1-month quarantine before placing them with the remainder of the herd is advisable. Controlling internal

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and external parasites is also important. Stomach worms and other internal parasites can reduce growth and performance—liver flukes may reduce fertility in bulls. External parasites reduce not only performance and overall health but also eye appeal. A good hair coat free of lice, ticks, and flies may be important when displaying bulls to potential buyers. Many products are available to control both internal and external parasites, and appropriate measures should be taken.

NUTRITION

Adequate nutrition is vital since it allows young bulls to more completely express genetic potential for growth, which predicts potential performance of eventual offspring. More importantly is that good nutrition also helps puberty begin on time, allowing for moderate breeding use by 15 to 17 months of age. Severe under-nourishment may cause irreversible testicular damage in young bulls and decreased sperm production in mature bulls.

It is still argued as to whether weanling bulls should be fed for maximum gain on a full-feed performance test or for more moderate gain on forage. The former approach sometimes results in excess fatness, which can temporarily reduce breeding performance and sperm quality.[2, 3] The moderate-gain approach may avoid these problems but precludes the chance for maximum gain. Breeders should refer to their association regarding specific test conditions.

Full-feed tests usually last 112 or 140 days, using diets designed to achieve potentially maximum gains. At as early as 7 to 9 months of age, bulls are slowly introduced to high-energy diets over a 3-to-4-week period, which prevents illnesses resulting from an abrupt change from a diet of milk and grass to one that is high in grain. Grain is added gradually to the ration until it supplies the desired level of nutrients. At that point, the official gain test begins. During this time, bulls are allowed either to eat ad libitum or be limit-fed about 3 percent of their body weight each day to maximize gain. When this approach is used with bulls of straight or percentage Brahman influence, rations should contain at least 20 percent roughage to avoid founder. Regardless of breed, full-feed rations should contain at least 10 percent roughage.

Specific ration design and ingredients for full-feed tests are not listed here because the cost, availability, and nutrient content of ingredients vary by year and region. However, rations should be designed according to National Research Council[5] standards for nutrient requirements in growing bulls. These requirements vary according to weight and desired rate of gain.

As the name implies, a forage performance test relies mostly on forages for nutrients. These tests usually last up to 10 months or longer, and for that reason, it may require both perennial and annual forages as the main part of the diet. When necessary, supplements are given to overcome nutrient shortages and reduced forage intake resulting from inclement weather. Clearly, average daily gains on forage performance tests are lower than that from full-feed tests, but over-fatness is avoided to reduce the potential for a temporary reduction in fertility. Nevertheless, when forage is adequate in growth and quality, some bulls can gain an average of 3 or more pounds a day.

Although full-feed tests are of shorter duration than forage tests, both cost about the same. However, it is important to measure young bulls for growth using either type of test. This allows for growth rankings to indicate potential performance of offspring from each bull.

Mature bulls also need adequate nutrition. Severe under-feeding and poor grazing conditions that result in dramatic weight loss will lower sperm production and quality. Over-feeding can also reduce sperm quality.[2, 3] Since during the breeding period, bulls have access to the same diet as the cows, grazing and supplements that produce good body condition in females will also suffice for bulls. At a minimum, daily crude protein intake for mature bulls should be 7 to 8 percent (i.e., 3 to 4 pounds of crude protein) for body maintenance and 10 percent or more for weight gain.[5]

Monitor the bulls' body condition before breeding starts. If bulls are thin, begin supplementing to increase body fat. Do not feed to over-fatness but to a level that gives them a smooth overall appearance. The ribs of adequately nourished bulls should not be visible. This equates to a body condition score of about 5.

Bulls also should have access to salt and a palatable mineral mix. Mineral mixes containing 6 to 12 percent phosphorus will usually suffice. The lower percentage is appropriate when bulls are grazing a well-fertilized pasture. The mineral mix's calcium content should range from 10 to 15 percent under normal grazing conditions or when moderate concentrate feeds are given.

FEEDING COTTONSEED PRODUCTS

Cottonseed products have been used successfully for years as a concentrated source of protein in cattle rations. During the 1980s, concern arose over the use of cottonseed products in the diet of young bulls. The naturally occurring gossypol contained in cottonseed

can temporarily reduce sperm quality in young bulls when fed at excessive levels for long periods. However, the severity of these problems varies because the toxicity effects of gossypol are influenced by cotton plant variety, cotton oil extraction procedures, diet content of cottonseed products, and length of feeding period. Consequently, some degree of caution is warranted, but cottonseed products are completely safe in the diet of young bulls if these guidelines are followed[5]:

- Whole cottonseed should be limited to 10 percent or less of a young bull's total diet (15 to 20 percent for mature bulls).
- Solvent-extracted cottonseed meal (a process used by 95 percent of Texas and Oklahoma cotton oil mills) should be limited to 5 percent or less of the total diet.
- Mechanically extracted cottonseed meal (used by less than 6 percent of Texas and Oklahoma mills) can be fed at a level of up to 15 percent of the total diet.

These recommended levels fall within the range of what typically has been fed over the years with no negative effects on reproductive performance. If the recommended levels of cottonseed products supply too little of crude protein in the ration, add different protein sources (e.g., soybean, guar, fish, peanut, alfalfa, or other meals) to meet deficiencies.

ASSESSING FERTILITY

Whether in young or mature bulls, a fertility assessment is required before breeding performance can be predicted. For a bull to impregnate females, the requirements are more complicated than expected. Bulls should, of course, be essentially disease-free and in overall good health.

They then must have enough libido to pursue, mount, and serve an estrus female. This involves travel over short or long distances in varying terrain, requiring sound feet and legs. Copulation requires functional genitalia free of abnormalities. Finally, quality sperm must be deposited.

No single test can assess each characteristic described above, but a breeding soundness exam (BSE) should be the minimum test performed annually on all breeding-age bulls. Examinations should be conducted about 60 days before breeding season starts. This not only allows time to replace bulls, if necessary, but also minimizes the time between examination and the start of breeding. A BSE performed at the end of breeding can determine whether a bull has undergone any changes that may have compromised his expected performance during the breeding season. Veterinarians familiar with semen collection and evaluation can perform a BSE, which includes:

- Visual assessment of eyes, teeth, feet, legs, and external genitalia.
- Internal palpation of accessory sex organs (seminal vesicles and prostate).
- Electroejaculation for a semen sample collection and sperm evaluation.
- Scrotal measurement.
- Physical exposure and examination of genitalia.

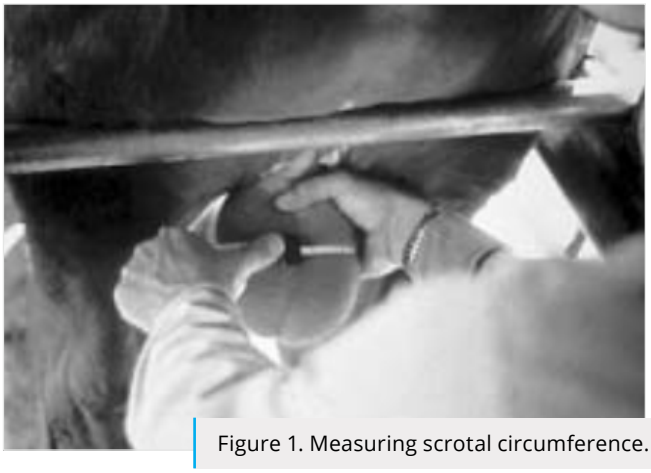

Figure 1. Measuring scrotal circumference.

Both functionality and longevity should be considered when evaluating bulls for structural correctness. The mouth, teeth, and eyes are examined. Research has shown that good vision[6] is the most important sense a bull uses to detect estrus, though sense of smell may also contribute.

In observing genitalia, both testicles should be descended into the scrotum and be the same size. Swelling or other reasons for disproportionate size may indicate injury, illness, or other testicular abnormalities. The testicles will also be palpated for texture. They should be well-formed but not hard.

TABLE 1. SCORING SYSTEM AND RECOMMENDED SCROTAL CIRCUMFERENCE FOR BULLS OF VARIOUS AGES.

Age	Very Good	Good	Poor
12–14 months	>34 cm	30–34 cm	<30 cm
15–20 months	>36 cm	31–36 cm	<31 cm
21–30 months	>38 cm	32–38 cm	<32 cm
Over 30 months	>39 cm	34–39 cm	<34 cm

(Adapted from the Society of Theriogenology)

TABLE 2. CURRENT RECOMMENDATIONS MINIMUM SC IN BULLS	
Age (Months)	**Scortal Circumference**
≤15	30 cm
≥15–18	31 cm
≥18–21	32 cm
≥21–24	33 cm
≥24	34 cm
(Society for Theriogenology, 2018)	

The scrotal circumference encompassing the middle of the paired testicles will be measured, which is one of the most important measures taken during a BSE (Fig. 1). Because testicular size affects sperm quality, bulls with acceptable scrotal measures (Table 1) produce more sperm with a higher degree of sperm cell normality than bulls with scrotal measurements below accepted standards.[7] Testicular size also affects the onset of puberty in bulls, with earlier puberty in those with large testes.[8]

Puberty begins later in straightbred and crossbred Brahman breeds than in British and Continental breeds, partially because of a smaller scrotal circumference. Therefore, it is important that producers of Brahman-influenced breeds select for increased scrotal circumference, which results in earlier puberty (Table 2). Furthermore, female offspring from bulls with large scrotal measures will reach sexual maturity sooner than daughters from bulls with scrotal measures below acceptable standards.[9] Consequently, inadequate scrotal size in bulls has both short- and long-term negative effects on reproduction in a cow herd. Finally, since scrotal circumference is heritable, selection for increased scrotal size can improve reproductive performance.[10] Some breeds report expected progeny differences (EPD) for scrotal circumference, and selection using scrotal circumference EPD is superior to simple phenotypic measures in reducing age at puberty in daughters.[11]

Sheath character is important in Brahman-influenced bulls. Extremely pendulous sheaths (Fig. 2) are undesirable since they are more likely to be injured during travel and even during copulation. The incidence of sheath problems in Brahman and Brahman crossbred bulls is variable, but observations at slaughter indicate that about 10 percent of such bulls have pendulous sheaths, resulting in severe penile lesions. Clearly, sheath injury that also involves injury to the penis can interfere with breeding activity. Sheath character is heritable and can be altered through genetic selection.[12]

Internal examination of the seminal vesicles and prostate may reveal swelling that could indicate infection or other abnormalities. Electroejaculation will provide semen samples. Semen evaluation consists of microscopic examination of sperm for motility, concentration, and normality. During electroejaculation, the veterinarian exposes the penis for potential abnormalities. Both acquired and congenital abnormalities can interfere with—and even preclude—successful copulation. These conditions include warts, swelling, deviations, lacerations, penile hair rings, and persistent penile frenulum. In young bulls nearing puberty, this procedure may reveal pre-pucial adhesions that are easily corrected.

From the results, bulls are classed as satisfactory potential breeder, unsatisfactory potential breeder, or deferred (indicating that the bull should be retested at a later date). Although accurate, a BSE is nothing more than a snapshot of a bull's breeding potential at a particular time. Since a bull's physical condition and sperm production can change, a BSE should be conducted annually on all bulls before breeding season starts. Young bulls classified as deferred because of age will eventually mature and should improve in fertility. Such bulls should be tested again later to determine if improvements have occurred.

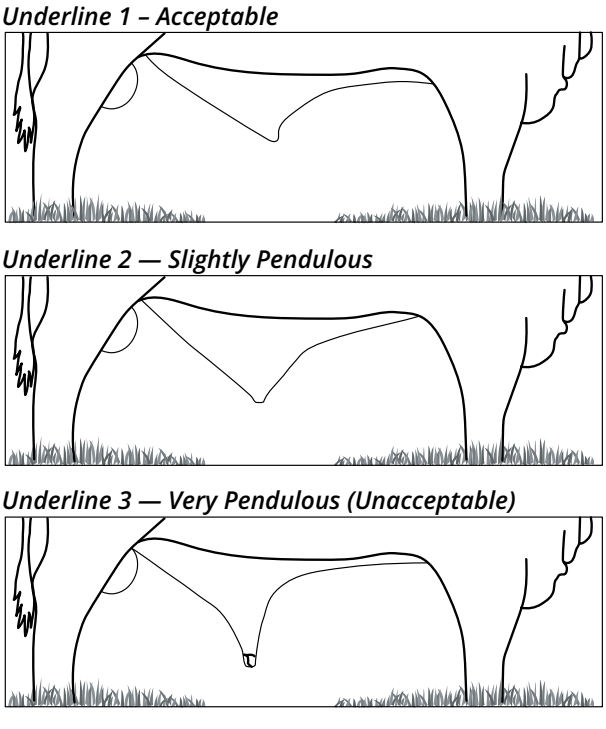

Figure 2. Sheath characteristics in Brahman and Brahman crossbred bulls.

LIBIDO AND SERVING CAPACITY

Quality semen, good health, vision, and sound feet and legs are only part of the bull fertility picture. Libido and serving capacity are also important components. Libido is defined as sexual desire—serving capacity is the ability to complete the act of mating. Both of these characteristics differ among bulls and are distinctly different components of fertility.

High libido is conducive to high fertility, but desire is only a precursor to successful mating. Consequently, some bulls with high libido cannot, for various reasons, successfully service a cow. In these instances, the usual culprits are lameness, inadequate erection, or genital injury or abnormalities. If these conditions are temporary, the ability to mate successfully may return. But if permanent, such bulls should be culled. Other bulls may have little or no libido, obviously leading to low serving capacity.

Unfortunately, libido and serving capacity do not correlate well to BSE test results. Bulls may possess quality semen but may be unacceptable breeders because of lack of desire or mating ability. However, libido and serving capacity are influenced by genetic heritage[13] and vary among sires of the same breed. Apparently, a certain amount of the male hormone testosterone is involved, but higher levels of the hormone do not increase libido. Other variables such as degree of muscling, coarseness of hair, and size of neck crest neither indicate nor predict the degree of libido or serving capacity.[14]

Observing bulls during the breeding season for their ability to mate is good management, but tests have been developed to assess serving capacity in bulls. The first, a "pen" test (Fig. 3), is recommended for Brahman-influenced bulls.[15] Estrus females are penned with bulls at a female-to-male ratio of 1.5:1 or 2:1. Usually no more than eight females are penned with up to five bulls at one time. Two (preferably three) observers count sexual events, including mounts and completed services in a 30-minute period. Bulls achieving two or more services in the 30-minute period are considered high-serving capacity. Bulls completing only one or no services are considered low-serving capacity. The disadvantage of the pen test is that it requires estrus females. When many bulls are tested, females are given estrous synchronization treatments to ensure adequate numbers for the pen test.

Figure 3. A "pen" test is recommended for Brahman-influenced bulls.

The second method of measuring serving capacity can be used on British and Continental bulls and involves stanchioned females, either estrus or not. Female-to-male ratio is 1:1. Bulls achieving more than three services in a 20- to 30-minute period are considered high-serving capacity, while those achieving two or three are moderate. Bulls achieving one or no services are classed as low. The advantage to stanchion tests is that fewer females, either estrus or not, are required.

The degree of serving capacity is important. Many research trials (not all) have shown that high-serving-capacity bulls, compared to low bulls, impregnate more females and in fewer days. This translates into higher production through more pounds of calf. In two trials[1], high-serving-capacity bulls increased pounds of calf weaned per cow by an additional 60 to 98 pounds, compared to that of low-serving-capacity bulls. Since serving capacity is heritable, selection for increased serving capacity can increase reproductive performance.

Young bulls without breeding experience occasionally show low serving capacity when first tested, and an accurate assessment may require at least two tests given 3 to 10 days apart. Mature bulls usually can be measured accurately with only one test.

BREEDING PRESSURE AND USAGE

Typically, a bull-to-cow ratio of 1:25 is recommended. This ratio is normally adequate, but research shows that it can be wasteful—particularly for highly fertile bulls and in situations where bulls do not have to travel long distances to find cows. With proper management, most breeds of bulls will reach puberty at 12 to16 months old and most—but certainly not all—yearling bulls should be capable of breeding females. For this reason, it is especially important to do BSEs on yearling bulls. A lighter breeding ratio is usually appropriate for yearlings, which is usually around 1:15. To reduce the risk of injury to yearling bulls, they should not be grouped with older bulls.

A California study[16] used DNA paternity testing on 5,053 calves to identify the sire from a group of 263 bulls that sired 15 calf crops over a 3 year period. All bulls passed a BSE, multiple-sire breeding pastures were used, and the bull-to-cow ratio was constant at 1:25. The number of calves sired per bull averaged 19 head per breeding season but ranged from 0 to 61 head. In any given breeding season, 4.4 percent of the bulls sired zero calves. In 40 percent of the calf crops, at least one bull sired only one calf and at least one bull sired more than 50 calves. Bulls were classified (i.e., number of calves sired) as High, Medium, or Low Prolificacy. The correlation between the first breeding season and subsequent breeding season prolificacy was 0.45. This indicates that prolificacy has a tendency to remain unchanged in some bulls. Research from Australia[17] reported results similar to the California study. These studies demonstrate the variation that can exist between individual bulls within a population. The cost of this technology is going down, which is now about $15.00 per calf, and is becoming a viable management tool for some producers.

Many producers run mature and young bulls (i.e., less than 4 years old) together in the same breeding pasture. This may not be a good practice, since mature bulls are generally dominant, giving younger bulls little or no chance to breed. If these young bulls are particularly valuable because of their genetic background, much of their contribution to production is clearly prevented. It is best to separate bulls less than 4 years old from older bulls and use them in at least two separate breeding pastures. This also reduces chances of injury from fighting that occurs when the two age groups are combined.

In multiple sire pastures, dominant bulls may have access to more females than submissive bulls do. This is probably acceptable if the dominant bulls are indeed fertile, but dominant bulls with low semen quality or low serving capacity clearly impede good reproduction. Producers should remember that bull fertility has many components, making a complete fertility assessment fairly complex.

A bull's degree of dominance may also be influenced by its weight. It may be beneficial to separate bulls by weight, but separation by age is likely to circumvent any dominance associated with size.

To reduce an assumed level of excess breeding pressure on bulls, producers occasionally rotate bulls in and out of the breeding pasture at frequent intervals, which is typically every 14 to 21 days. The amount of breeding pressure that bulls can tolerate is unknown, but trials show[1] that bulls can withstand more pressure than is usually expected. Furthermore, frequent ejaculation does not reduce sperm quality or numbers[18], and fertility remains acceptable even under heavy pressure.

Perhaps the biggest problem arising from rotation is that producers can unknowingly remove their most fertile bulls from the pasture at a time they are needed most. Replacing them with a potentially less fertile bull can lower pregnancy rates. In practice, rotation is effective only when the serving capacity for each bull is known. Bulls with high serving capacity should remain with the herd, while low bulls can be rotated—or, better yet, culled.

Purchased bulls should be procured from an area environmentally similar to their eventual destination. Bulls reared in dry, cool climates may require months of adaptation if moved to warmer, more humid climates. This period of adaptation is often accompanied by a drop in fertility. In some instances, this decrease is dramatic and may last several months.

CONSIDERATIONS FOR CULLING

Bulls are most often culled for old age, which is appropriate because semen quality declines after age 6.[19] It is also at this age that mature bulls begin to lose their social dominance rank to younger, more aggressive bulls and have fewer chances at breeding. Especially valuable aged bulls (i.e., more than 7 years old) should probably be used in single-sire matings, but a drop in fertility should be expected due to age.

For best practice, bulls should be culled for poor vision, lack of desirable conformation, low-quality semen, and inadequate serving capacity. It may also be important to cull for poor disposition—simply from the standpoint of safety and prevention of injury to other animals.

From a genetic perspective, bulls that produce low-performing offspring should be culled. Also, take steps to prevent sires from mating their close relatives to avoid in-breeding if it is deemed undesirable. On the other hand, genetically superior sires are often retained past 7 years old, but usually for very specific matings in purebred operations or in situations where heifers are not retained as replacements.

SUMMARY

The following management techniques are recommended to ensure that bulls are given the best opportunity to contribute their fullest production potential and to reduce the chances of low fertility:

- Use bulls with acceptable genetic potential for economically important traits such as growth, carcass quality, maternal value, and calving ease.

- Control diseases with appropriate vaccinations (consult a veterinarian).
- Provide adequate nutrition from the weaning age through maturity. Undernourished bulls are likely to have low fertility.
- An annual breeding soundness exam (BSE) should be conducted on all breeding-age bulls at about 6 to 8 weeks before the start of breeding. Do not use bulls that fail a BSE.
- Avoid bulls with small scrotal circumferences and extremely pendulous sheaths.
- Observe bulls throughout breeding for their ability to mate. Perform serving-capacity tests when feasible. Bulls with low-serving capacity settle fewer cows than high-serving-capacity bulls.
- Use separate breeding pastures for bulls less than 4 years old. Running them with older bulls may cause dominance problems, affording fewer chances for young bulls to mate.
- Cull bulls with poor vision, low semen quality, lack of desirable conformation, and those producing inferior calves.

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DETERMINING PREGNANCY IN CATTLE

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Determining pregnancy in cattle is an important management practice. The ability to determine pregnancy can allow you to make timely culling decisions and focus the resources of your operation on sound, reliable breeders. With experience, you can determine the fetal age which will allow you to predict expected calving dates and plan for the necessary labor at calving time. Pregnancy determination can also help you manage feeding to meet the high nutritional demands of gestation, calving, lactation, and rebreeding more effectively.

Knowing expected calving dates can also be an advantage when marketing bred replacement heifers. Potential buyers often want to purchase females whose calving dates coincide with those of their present herd.

INCREASING HERD PRODUCTIVITY

A cow-calf producer's economic returns depend largely on the percent calf crop and the weaning weight of the calves to be sold. You can compute your calf crop percentage by dividing the number of calves raised to weaning age (7 months) by the number of cows in your herd at the beginning of breeding season.

Percent Calf Crop and Weaning Weight

Table 1 shows the cost per pound of calf produced for various production levels with an operating cost of $750 per cow per year. To determine the required level of production for this example, take an arbitrary selling price of $1.78 per pound and locate the break-even point in Table 1.

Weanling calves weighing 450 pounds would require a 90 percent calf crop to break even. If only a 60 percent calf crop is produced, the needed break-even point would be 93 cents higher than the $1.78 market value. Calves weighing 500 pounds would break even at just over an 80 percent calf crop, and calves weighing 550 pounds would break even at a 74 percent calf crop.

From another perspective, lightweight calves averaging 350 pounds with only a 60 percent calf crop would need to sell for $3.50 per pound to break even.

You can see the economic importance of calf crop and its interaction with weaning weight in Table 2. Break-even prices decrease as calf crop and weaning weight increase. This is true under any annual operating cost per cow.

TABLE 1. PRODUCTION COST PER POUND OF CALF AT $750 PER COW OPERATING COST.

Weaning weight (lb)	550	500	450	400	350
Calf crop (%) 100	550[1] $1.36[2]	500 $1.43	450 $1.60	400 $1.81	350 $2.07
90	495 $1.36	450 $1.60	405 $1.78	360 $2.01	315 $2.31
80	440 $1.70	400 $1.81	360 $2.01	320 $2.27	280 $2.61
70	385 $1.94	350 $2.07	315 $2.31	280 $2.61	245 $2.99
60	330 $2.27	300 $2.43	270 $2.71	240 $3.05	210 $3.50

[1] Top figures indicate pounds of calf produced per cow.
[2] Bottom figures break-even price at a given production level with a $14/cwt slide for calf weight.

Management Practices To Improve Production

The challenge for cow-calf producers is to use management techniques that stimulate production without drastically increasing operating costs. You can improve weaning weight through a number of methods, including:

- Internal parasite control.
- Using growth stimulants.
- Using sires with the genetic potential for increased growth.

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TABLE 2. BREAK-EVEN PRICES AT VARIOUS LEVELS OF PRODUCTION AND ANNUAL COSTS OF PRODUCTION.					
Calf crop (%)	Weaning weight (lb)	Pounds of calf per cow	Annual costs per cow		
			$600	**$700**	**$800**
90	550	495	$1.21	$1.41	$1.61
80	500	400	$1.50	$1.75	$1.60
70	450	315	$1.90	$2.22	$2.54
60	400	240	$2.50	$2.92	$3.33

[1] Break-even prices per pound of calf, dollars.

- Providing adequate herd nutrition which also helps optimize reproduction

Another effective and inexpensive way to improve reproduction rates is through annual pregnancy testing and culling of sub-fertile cows. In addition, culling open cows—and sometimes even bred cows—during an extended drought may be necessary to balance stocking rate with declining forage supplies. However, there may be unique years when a drought during the breeding season is followed by rain later in the year. If forage conditions improve significantly, so may chances for re-breeding. Under such circumstances, "low risk" cows (e.g., middle-aged cows that are physically sound and proven breeders) are sometimes kept over until the next breeding season and given a second opportunity. This is also an acceptable option if replacement costs are higher than the cost of retaining the open cow. Remember that open heifers and aged cows are "high risk." They should probably never be allowed a second breeding opportunity. Regardless of environmental considerations or replacement costs, any cow that is open more than once should be culled. If you follow this practice annually and your cows are under otherwise good management, pregnancy rates will increase. Table 3 shows that the increases in the pregnancy rate in Texas test herds were sustained at an acceptable level.

Visual observation is also important in culling decisions. Some pregnant cows should be culled on the basis of age. Other determining factors of poor breeding stock are conditions of the udder, feet, legs, and teeth. The decision to cull an open cow may also depend on her reproductive history.

Culling decisions may also depend on the animal's monetary value. You can retain highly valued registered females that fail to conceive until some or most of their initial cost is recovered. This strategy is prudent as long as these animals are free of abnormalities of the reproductive tract and have previously produced at an economically acceptable level.

TABLE 3. EFFECTS OF ANNUAL PREGNANCY TESTING AND CULLING OF SUBFERTILE COWS ON SUBSEQUENT HERD FERTILITY.					
	Percent pregnant by year				
	1	2	3	4	5
Herd					
1	75	97	96	93	98
2	64	56	84	89	–
3	59	66	79	92	85
4	85	90	94	–	–
5	82	94	93	93	–
6	74	76	86	94	98
7	49	89	92	89	89

Sprott and Carpenter, 1994; Unpublished data.

PALPATING TO DETERMINE PREGNANCY

Pregnancy determination via palpation is made by inserting the arm into the rectum and feeling the reproductive tract for pregnancy indications.

Equipment

Little equipment is needed in palpation. The palpator should wear a protective plastic sleeve covering the hand and arm up to the shoulder. The sleeve guards against disease and prevents irritation of the arm. Use an obstetrical lubricant or mineral oil to make entry into the rectum easier. Do not use soap or detergents as a lubricant as both are irritants. Plastic sleeves may tear after several uses, reducing protection. If the sleeve tears, replace it before palpating the next animal.

The chute for holding the animal during palpation should allow her to stand in a normal position. It should have a front wall or gate and a bar just above the

animal's hocks in the rear (Fig. 1). This bar keeps the cow from kicking and protects the palpator. Include an entrance gate in the chute at the rear of the animal to allow the palpator to enter and exit easily. Provide a gate to swing across the crowding chute and fasten it in front of other animals coming behind the palpator. You may use squeeze chutes but do not need to catch the cow's head for this procedure.

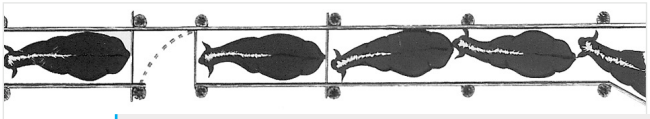

Figure 1. Chute arrangement for restraining cows.

Palpation alone takes only a few seconds. The speed of pregnancy determination depends on three factors: management of the cows as they come through the chutes, the stage of pregnancy, and the palpator's experience level. Ideally, an experienced palpator can examine several hundred head of cattle in a normal working day. However, the process is much slower if the palpator has to help bring the cattle into the chute or climb over the chute wall to get behind the animal to palpate her.

To ensure the safety of the animals and the palpator, you must practice certain precautions:

- Restrain the animal so she cannot jump over the side of the chute or kick the palpator.
- Prevent other cattle from coming up behind the palpator as he or she attempts to determine pregnancy.
- Replace broken boards and check for exposed nails in the chute that could injure the animal's legs.
- Place cleats across the floor if it is slick to help stabilize the animal's footing.

These precautions make it much more likely that the cow will remain calm and stand quietly during palpation. In addition, the process becomes more efficient and safe for the cow and the palpator.

Reproductive Tract Structures

Thorough knowledge of the structures of the female reproductive system is essential for successful palpation. Only the reproductive tract and associated organs will be discussed here, but you should be aware that endocrine glands located in other parts of the body—particularly the brain—are also involved in the sexual cycle. Figure 2 is a general diagram of the reproductive tract.

The **vulva** is the external portion of the reproductive tract and can be seen as two prominent lips. Its size may vary with the animal's age and between breeds. Brahman-influenced females usually have a larger vulva than do cattle of English and European breeds.

Figure 2 (right to left) shows the next portion of the tract: the **vagina**. It serves as a receptacle for semen during natural mating, is a thin-walled structure and is not easily felt during palpation.

The **urinary bladder** (not shown in Fig. 2) is underneath the vagina. It may extend beyond the pelvic brim and

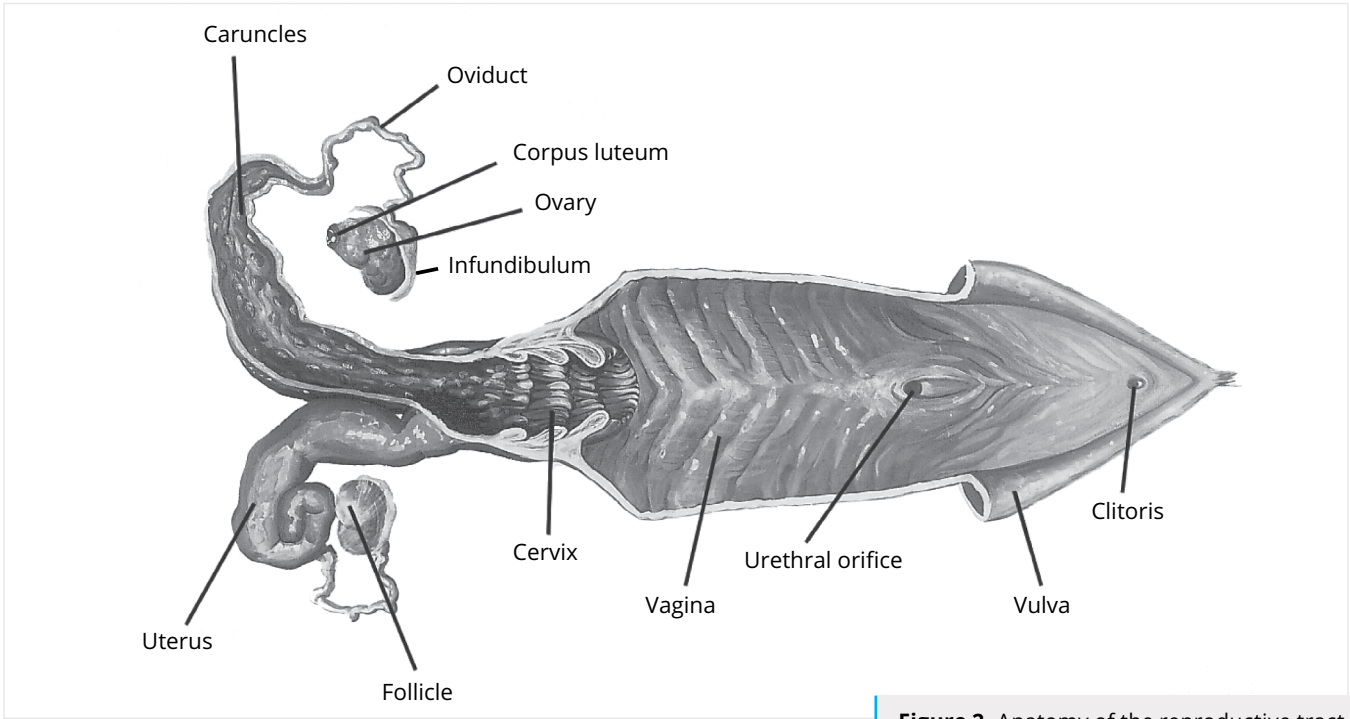

Figure 2. Anatomy of the reproductive tract.

slightly into the body cavity, particularly when it is full of urine. During urination, the bladder empties through a small opening (urethral orifice) on the floor of the vagina, eventually exiting the body through the vulva.

The **cervix** is a thick-walled structure attached to the vagina. It is comprised of connective tissue, which feels much like gristle. Because of the thickness and firm feel, the cervix is a good landmark for orientation while you are palpating. The internal walls of the cervix are folded and protrude toward the exterior of the reproductive tract. These folds are sometimes called *cervical rings*. The surface of these rings is lined with mucus-secreting cells. This mucus is often seen smeared on the rumps or flowing out of the vulva of cows in estrus. During pregnancy, the mucus becomes much thicker than at estrus and plugs the cervix. This protects the developing embryo from foreign debris in the vagina. The cervix may also act as a sperm sieve, trapping some abnormal sperm cells and allowing normal sperm cells to travel into the uterus and oviducts.

The **uterus** is Y-shaped with a right and left horn. The horns share a connecting region known as the body. During artificial insemination, semen is deposited in the uterine body. The walls of the uterus are lined with special glands that secrete *uterine milk* (the substance that nourishes an early embryo). By approximately 16 to 18 days of gestation, the placental membranes are well developed and extend into both horns of the uterus. About 38 days into gestation, these membranes begin attaching to the uterine wall at raised areas known as caruncles. Located throughout the uterus, these are the exchange points for nutrients coming from the dam. The placental side of these attachment points are called *cotyledons*. The cotyledon and caruncle form a combination known as a placentome (button). In mid- and late gestation, these buttons become firm and are easily detected when palpating the uterine surface.

The end of each uterine horn is attached to an **oviduct** (fallopian tube). The oviducts are small, tube-like structures. Because they are very small, they are difficult to feel. They transport sperm cells to the site of fertilization (the upper third of the oviduct) and an embryo back to the uterus if conception occurs. At the end of each oviduct is a thin, cup-like membrane (infundibulum) that is difficult to feel. It catches the egg (ovum) as it is expelled from an ovarian follicle during ovulation and transports the egg into the oviduct for eventual fertilization. For this reason, each ovary is located close to the infundibulum.

The entire reproductive tract is attached to a thin suspensory membrane known as the **broad ligament**. This elastic ligament will stretch and move within the pelvic and body cavities to allow the reproductive tract to move. This movement is necessary due to the weight of the fetus and the crowding of the tract by other internal organs. The broad ligament is attached to the upper pelvic and body cavities and acts as a cradle for the tract. It also contains arteries and veins that supply the tract with blood to nourish the tissues.

Figure 3 shows an interior view of the reproductive tract and broad ligaments of an open (non-pregnant) cow. Table 4 gives a general size description of the various parts of the tract in an open cow. The complete tract with all parts included varies in size and feel. This depends on the stage of the estrous cycle and on the breed, size, and reproductive history of the animal. Generally, the size of an entire open tract is 12 to 18 inches long. In young heifers that have just reached puberty, the tract may be only 8 inches long. The tract of mature cows that have had several calves may extend to 24 inches.

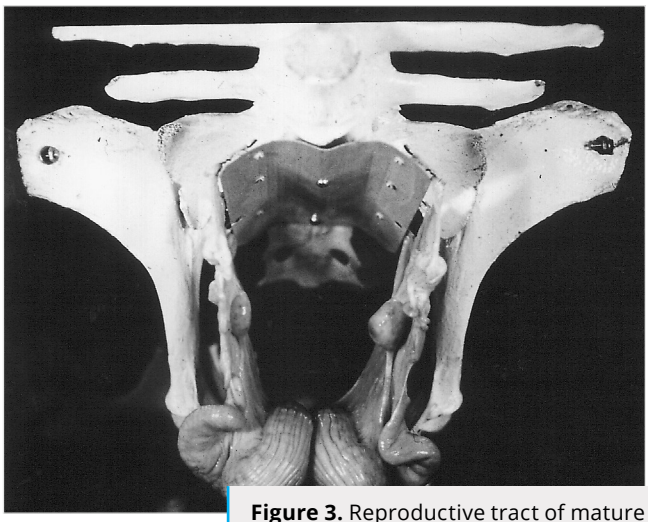

Figure 3. Reproductive tract of mature cow on floor of pelvis.

Changes Associated with Pregnancy

The sexual cycle of a normal cow is characterized by estrus (heat) periods that occur at 21-day intervals. Figure 4 diagrams the estrous cycle and some of its activities.

At estrus, the cow is influenced by estrogen being produced by follicles on the ovaries. This hormone causes her to display estrus. Within 24 hours of the initial stages of estrus, one of the follicles ruptures and releases a single ovum (egg). This is *ovulation*. The egg moves into the infundibulum and eventually down into the oviduct. The cavity on the ovary left by the ruptured follicle develops into a new structure known as a corpus luteum (Fig. 2). The corpus luteum produces *progesterone*, the hormone responsible for

TABLE 4. SIZE CHARACTERISTICS OF REPRODUCTIVE ORGANS IN AN OPEN (NON-PREGNANT) COW.			
Organ	**Size**	**Shape**	**Remarks**
Vagina*	Varies with position of tract.	Thin-walled, hollow tube.	Difficult to feel during palpation.
Cervix	2 to 12 inches long. ¾ to 8 inches in diameter. Average diameter 1½ inches.	Tube-like and thick-walled.	Cervix is tube-shaped, but may be funnel-shaped in some cows or bent and crooked. Firm, gristle-like feel. Good landmark.
Uterine Body	Interior: ¼ to ¾ inch long. Exterior: 1 to 3 inches long.	Intersecting region of the two horns.	Feels like soft, flat muscle. Not as firm as the cervix.
Uterine Horns	5 to 12 inches long, ½ to 1½ inches in diameter.	Tube-like and sometimes coiled. See Figures 4 and 7.	Feels meaty and soft to slightly firm, depending on stage of the estrous cycle.
Oviducts*	1/16 to ⅛ inch in diameter.	Long, crooked tube.	Difficult to feel because of the small diameter and soft texture.
Ovaries*	½ inch wide, ¾ inch thick, 1 inch long.	Rounded or elliptical shape.	Feels firm and distinct as if you were holding a grape or plum.

* It is not necessary to feel the vagina, oviducts and ovaries when palpating for pregnancy.

maintaining pregnancy. If conception does not occur with this ovulation, the uterus releases a hormone called *prostaglandin*. It regresses or destroys the corpus luteum.

Regression is complete by approximately 16 to 17 days into the cycle. Meanwhile, follicles continue to grow on the ovary. Since the corpus luteum has regressed and is no longer producing progesterone, a new ovulatory follicle is recruited. Within 4 to 5 days, the cow returns to estrus. The process of development and regression of a normal corpus luteum causes a cow to have her characteristic 21-day sexual cycle.

If the cow is mated during estrus, the sperm cells will travel from the site of deposition (the vagina) to the site of fertilization (upper third of the oviduct) within minutes. While there, the sperm cells undergo a 6- to 8-hour maturation period called *capacitation*. Only then can the sperm cells fertilize an egg. When the egg arrives at the fertilization site, the sperm cells are already there and have most likely undergone capacitation. The chances of fertilization and pregnancy average between 50 and 70 percent.

When fertilization occurs, the cow's physiological cycle begins a dramatic change. This leads to the development of a full-term fetus. About 8 days after fertilization, the embryo is transported to the uterus. At 16 to 17 days after fertilization, the embryo and its placental membranes begin to release a hormonal signal that prevents the usual release of prostaglandin from the uterus. As a result, the corpus luteum does not regress and continues to release progesterone to maintain the pregnancy. The embryo houses itself in the uterine horn nearest the ovary that produced the ovulating follicle. Therefore, an embryo found in the right horn comes from an egg produced by the right ovary, and vice versa. For this reason—particularly in cows that are open or may be in the early period of gestation—you must palpate both uterine horns.

The major changes in the structure of the reproductive tract after conception occur mainly in the uterus. Its shape, size, texture or feel, and location will change. The embryo will also grow. This growth is directly responsible for changes noted in the uterus. Figure 5 shows embryo or fetal growth by month and stage of gestation.

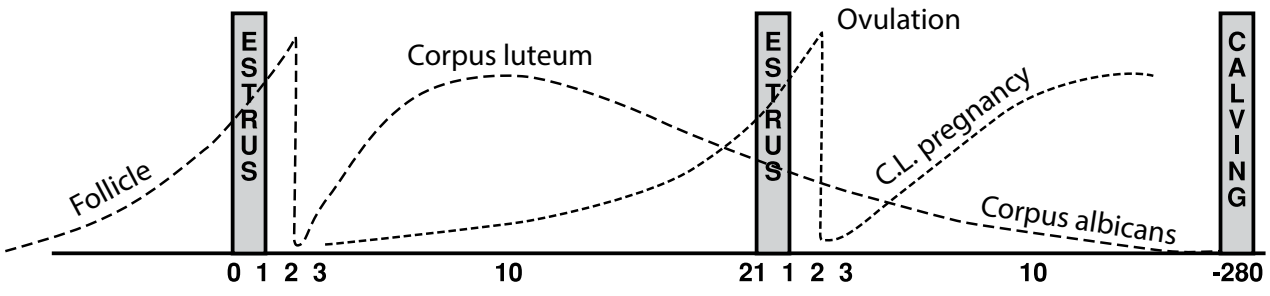

Figure 4. Note the cycle pattern is followed at approximately 21-day intervals.

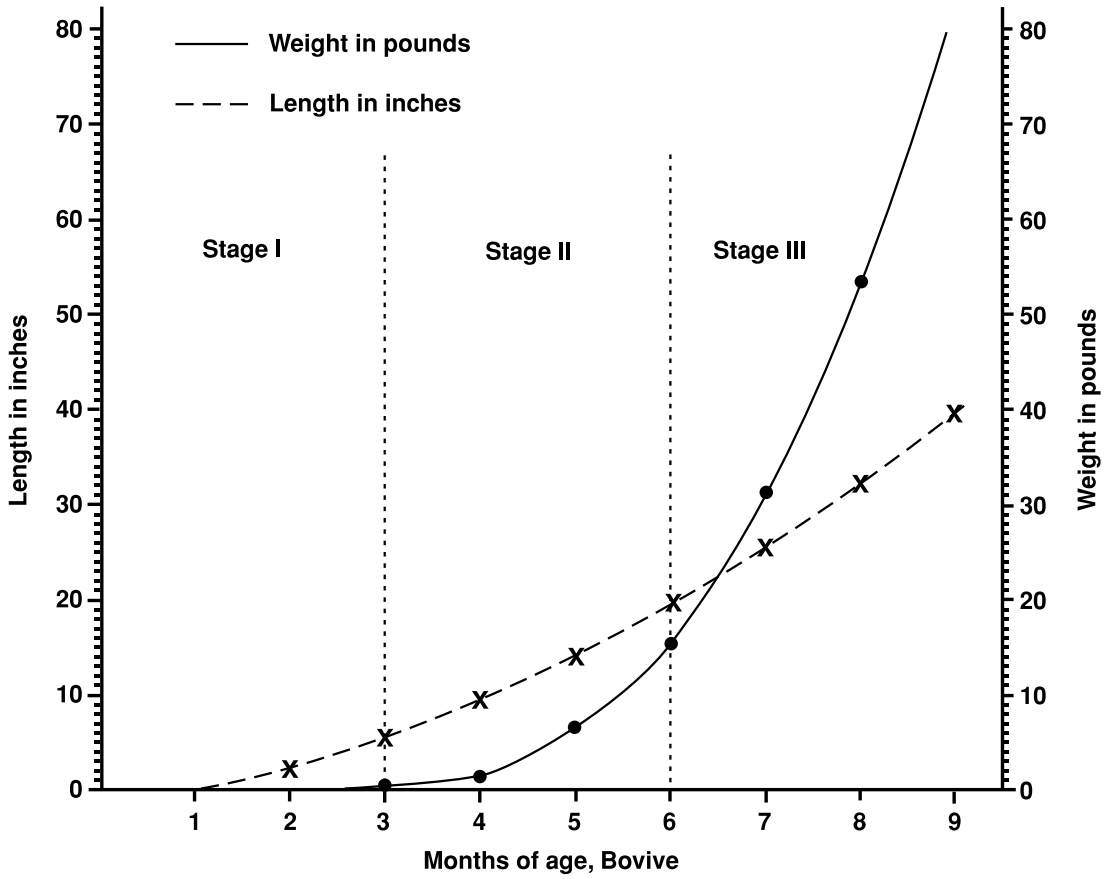

Figure 5. Growth of fetus. Parturition occurs approximately 280 days after fertilization.

DEVELOPMENTAL STAGES

There are three main periods of development in a young calf's life. The first period—the ovum—is the time from fertilization until the egg has divided enough times to take on a particular form. This occurs on approximately the thirtieth day when there is an enfolding of the layers of the developing egg. At this stage the newly developing animal is called an embryo. The period of the embryo lasts until the fetal membranes begin to attach to the lining of the uterus, which takes approximately 38 days. During the embryonic stage, various organs and systems are laid down. These include the respiratory, nervous, digestive, circulatory, and reproductive systems. As the embryo develops, it floats freely in uterine milk in the uterine cavity.

The fetus period begins when the embryo is approximately 38 days old and ends when the newborn is expelled at *parturition*, or birth (Fig. 5). During the fetus stage, continued attachment takes place at the numerous caruncles lining the uterus. These attachments provide transfer of nutrients and waste materials for the developing fetus. Birth occurs approximately 280 days after fertilization.

PALPATION TECHNIQUE

You may use either hand in palpation. With one hand, grasp the cow's tail as a handle while you palpate with the other. The hand used for palpation should be well lubricated and shaped into a wedge by bringing the fingers together as closely as possible.

Rectum

Push through the anus into the rectum with one continuous thrust. As your hand enters the rectum, fold your fingers into a modified fist by tucking your fingertips under (Fig. 6).

In this position, your hand will push the fecal material aside and straighten the rectum. Folds in the rectum do not straighten as easily if the fingers are pointed. The modified fist also eliminates the risk of puncturing the rectal wall with sharper, pointed fingers. Puncturing is rare, as the rectum is thick-walled and resistant. Cleaning the cow's rectum of fecal material is usually unnecessary. In early stages of learning however, cleaning the rectum will help you feel other structures more easily.

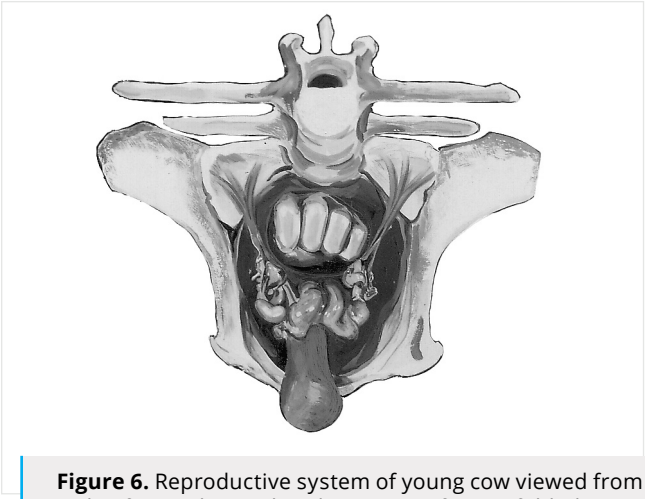

Figure 6. Reproductive system of young cow viewed from inside of animal. Note hand's position (fingers folded into a modified fist) inside rectum directly above uterine horns.

Rectal straining may result from the entry of your hand. This is a reflex response by the cow. Straining can be alleviated by simply moving your hand back and forth in a gentle massaging motion. If straining reoccurs, massage the rectal wall again.

Usually, the longer the examination, the more rectal straining you will encounter. Do not be upset by a small amount of bleeding, as this occurs occasionally and is not necessarily a sign of damage to the rectum. An indication of rectal damage is a sandpaper or gritty feeling, which means that the mucosa lining of the rectum has been rubbed off during palpation. If this occurs, it is best to stop palpating immediately.

Feeling through the rectal wall is similar to feeling through one or two layers of thin rubber. Most cattle are cooperative, so you should be able to detect and pick up the reproductive organs easily.

Experienced palpators usually learn to follow a consistent routine. When first entering the rectum, thrust the arm beyond the elbow and deep into the abdominal cavity. Feel in a downward direction toward the udder. Since late-term fetuses will be located here, initial deep entry allows palpators to determine pregnancy quickly and reduces time spent in the cow. If a fetus or other indications of pregnancy are not found in the abdominal cavity, palpators should move back toward the pelvic cavity. Most open tracts and early pregnancies will be located here. While feeling in or near the pelvic cavity, locate the pelvic brim. This is a good landmark for orientation. Most importantly, find the cervix and move forward to the uterus to determine pregnancy. Following this simple routine will help reduce palpating errors.

Paunch

Upon entry into the rectum and just past the pelvic brim, palpators may encounter the paunch (rumen). It is the first and largest of the cow's four stomachs (Fig. 7). It has a dorsal (upper) and ventral (lower) sac. The dorsal sac is forward and to the left of the pelvic brim. It may feel like the end of a football and be mushy or gritty. This protruding end of the dorsal sac may even extend into the pelvic cavity. In such cases you might mistake it for an enlarged uterus or late-term fetus. By mashing the paunch, you will notice an indentation which gradually smooths back to its original shape. This indicates that the paunch is full of feed. The paunch does not have the watery feel of a pregnant uterus.

The ventral sac of the paunch is deep in the body cavity and located toward the udder region. This sac lies either to the right or to the left side of the body depending on the gut fill. It has the same mushy or gritty feel as the dorsal sac and will indent if mashed with the hand.

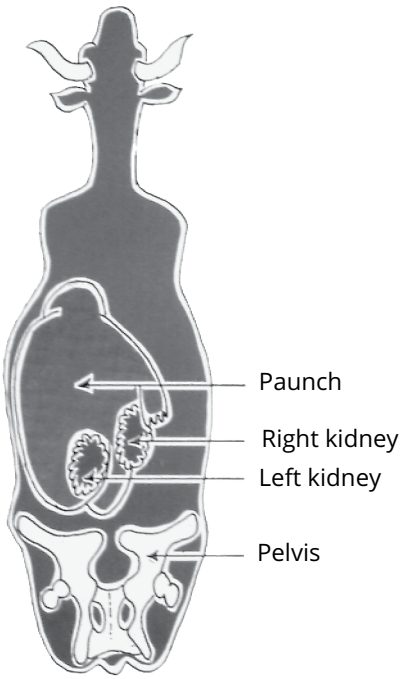

Figure 7. Position of paunch and kidneys.

Reproductive Tract

The open reproductive tract normally lies on the pelvic floor or against either pelvic wall. The horns of this tract are usually coiled on their front edge and may hang slightly into the abdominal cavity (Fig. 8) in older cows. Two characteristics confirm the absence of a pregnancy: (1) when palpated, both uterine horns in the open cow will feel thick-walled and have a meaty texture; and (2)

fluid will not be present in the horns. At this stage you can hold the entire uterus in your hand and palpate it from underneath or from the side. When learning to palpate however, it may be easier for you to feel the top surface (Figs. 8 and 9).

Tone (firmness) of the open horns varies with the estrous cycle. Shortly before and after estrus (under *estrogen influence*), the uterus will feel turgid or firm. During the period of the corpus luteum (*progesterone influence*), the uterine horns will feel flaccid or soft. Slight pressure with the middle finger (Fig. 9) will separate the horns, allowing you to palpate each horn. Both horns must be felt, since a pregnancy may occur in either. Inexperienced palpators sometimes have difficulty grasping the uterine horns. To overcome this problem, move the uterus down against the pelvic floor or to either pelvic wall. Flatten your hand and apply gentle pressure against the uterus to separate the horns.

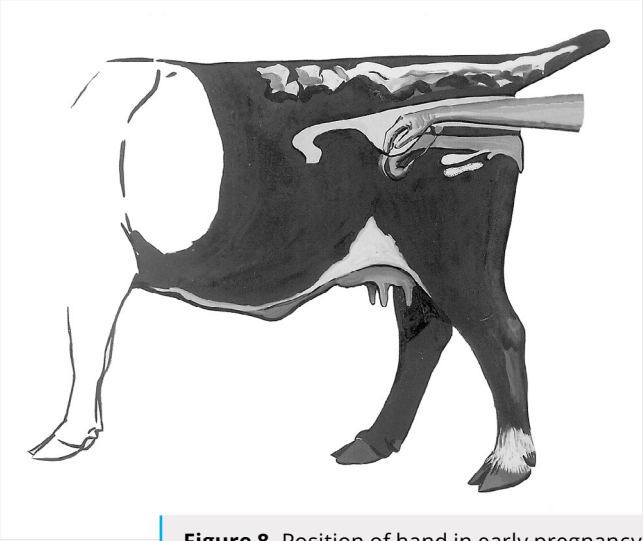

Figure 8. Position of hand in early pregnancy.

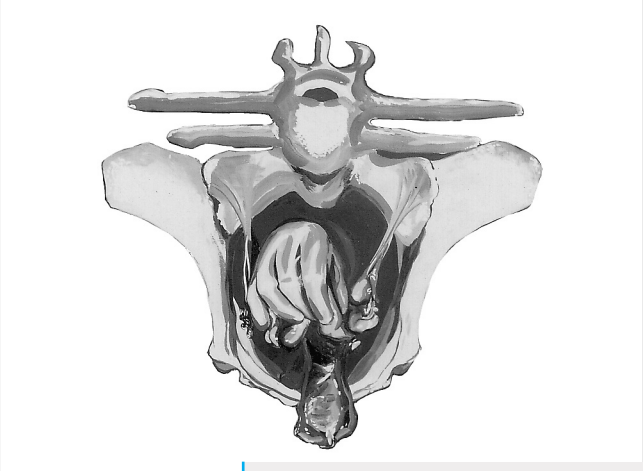

Figure 9. Separation of uterus horns.

The ovaries are in the broad ligament toward the end of the uterine horns or at their sides. However, it is not necessary to palpate the ovaries when determining pregnancy. The most important step is to feel the uterus for its texture and content.

DETERMINING STAGE OF PREGNANCY

Stage I: 30- to 35-day pregnancy

Because embryos at this early stage are delicate, beginning palpators should not try to feel them. However, an experienced palpator can detect pregnancy as early as 30 days after breeding. Palpation which at this early stage should be accompanied by good breeding herd records. These records help the palpator know the approximate breeding date of the animal.

In the early stage of pregnancy, the uterus is filled with a small amount of fluid and will feel slightly thin-walled. One horn is enlarged a little more than the other. At this stage you can determine the presence of the embryonic vesicle by carefully running the horn between your fingers in a milking action. You can feel the vesicle slide through your fingers.

At this stage the embryo is only about 1/2 inch long. The vesicle surrounding it is about 3/4 inch in diameter and filled with fluid—like a balloon filled tightly with water. However, the borders of this vesicle are indistinct. What you actually feel is something slightly smaller than a marble as it slides through your fingers. The uterus, in much the same location as a non-pregnant uterus, has not been displaced because of size or weight at this time. The outer embryonic vesicle—which occupies both horns—is rather thin with little fluid. It may be 18 to 24 inches long. By pinching the horn of the uterus carefully, you can feel the membranes of this vesicle as they slip between your fingers.

Stage I: 45-day pregnancy

Most palpators prefer that bulls be separated from cows at least 45 days before pregnancy determination. At 45 days, the horn of the uterus containing the fetus is somewhat enlarged and thinner-walled compared to the other. The fetus at this stage is about 1 inch long. The vesicle around it is egg-shaped and measures about 1 to 1½ inches long. You can feel the outer membrane—which contains fluid—through the uterine wall. The attachment of the membranes to the uterus has just taken place at about 38 to 40 days. Therefore, avoid moving the fetus about in the uterus. The caruncles on the uterus join the cotyledons on the fetal membranes for nutrient exchange. These two structures form the

placentome. Buttons cannot be felt by palpation until later in pregnancy.

Slipping of the fetal membranes is a valuable aid to early pregnancy determination. Although the membranes can be slipped at any stage of gestation, it is easiest to perform and of the most value between 40 to 90 days of pregnancy. The procedure involves picking up and gently pinching together the walls of either uterine horn. The palpator feels the fetal membranes as they slip between the thumb and fingers. Be gentle when using this technique, since the embryo and membranes are rather delicate in pregnancies under 45 days.

Stage I: 60-day pregnancy

The uterus will have enlarged considerably by this time and will be filled with fluid and the increased growth of the fetus (Fig. 10). The fetus now is about 2½ inches long and may have displaced itself into the abdominal cavity, indicating that the uterus has stretched. The cervix may be pulled over the pelvic brim; but the cervix, body, and horns of the uterus are within reach. In larger animals, this is a difficult stage for pregnancy determination. This is due to displacement and the distance from the anus to the developing fetus.

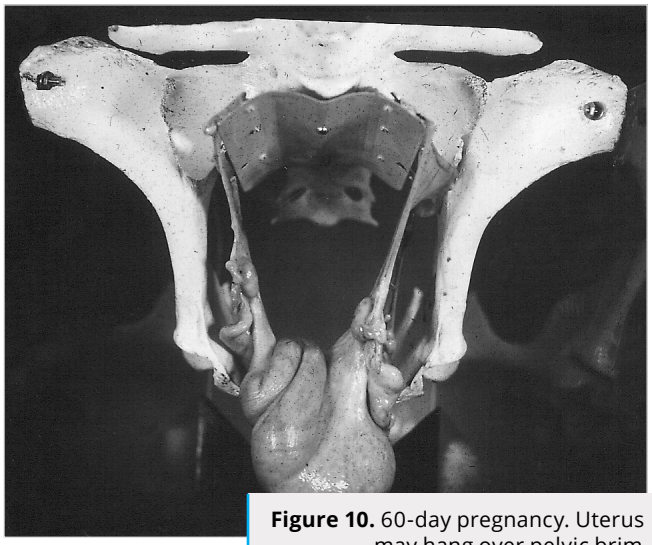

Figure 10. 60-day pregnancy. Uterus may hang over pelvic brim.

The uterine walls have thinned considerably. The best method of feeling the fetus is to bobble it with your hand so that, if you gently tap the uterus, the fetus swings like a pendulum and hits against the wall of the uterus and vesicle. The cervix remains on top of the pelvic cradle, and the uterine horns move toward—and possibly beyond—the brim.

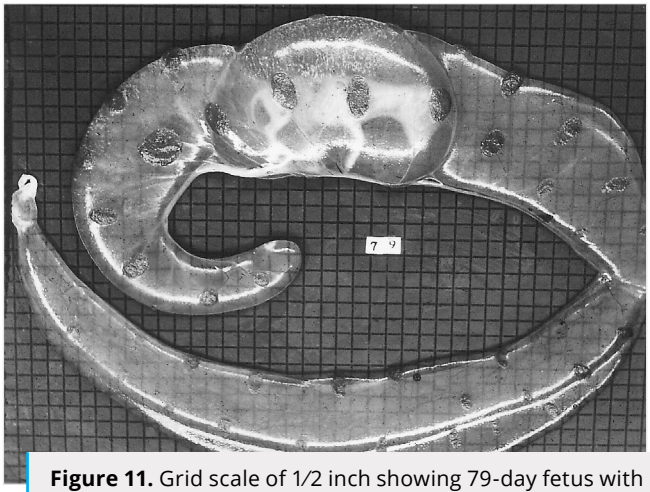

Figure 11. Grid scale of 1/2 inch showing 79-day fetus with surrounding membranes filled tightly with fluid.

Stage I: 90-day pregnancy

The fetus now is about 6 inches long and may have displaced itself into the abdominal cavity, indicating that the uterus has stretched (Fig. 12). The cervix may be pulled over the pelvic brim, but the cervix, body, and horns of the uterus are within reach. In larger animals, this is a difficult stage for pregnancy determination. This is due to displacement and the distance from the anus to the developing fetus.

You may have to consider factors other than the presence of the fetus at this stage. Consider displacement of the uterus as a possible indication of pregnancy. Another indication of pregnancy is enlargement of the uterine arteries with their characteristic pulsation. These arteries (one for each uterine horn) are in the forward fold of the broad ligament (Fig. 13), which supports the uterus. In a three-month pregnancy, the artery supplying blood to the pregnant uterine horn is about ⅛ to 3/16 inch in diameter. The artery feeding

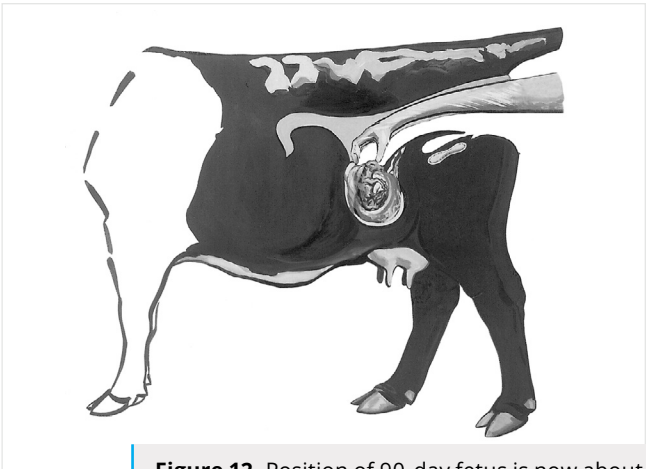

Figure 12. Position of 90-day fetus is now about 6 inches long. It has displaced itself over pelvic brim and down into abdominal cavity.

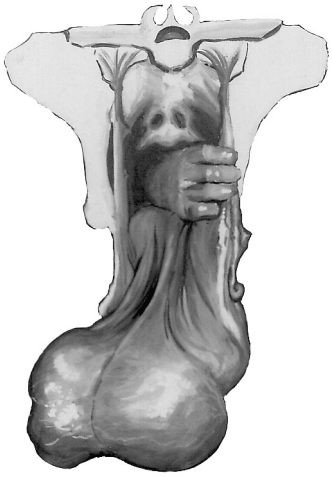

Figure 13. Tract lying on floor of abdominal cavity with palpation of uterine artery at 4-month pregnancy stage.

the non-pregnant horn is only half that size. When you grasp the artery, you can easily feel the pulse of the heartbeat as blood is carried into the uterus to nourish the developing fetus. Do not confuse the uterine artery with the femoral artery lying on the inside of the thigh which supplies the hind legs. The femoral artery is in the muscle, but may be palpated. Remember that the uterine artery is in the broad ligament and can be moved 4 to 6 inches, while the femoral cannot.

If you are unable to reach the fetus, the best indication of pregnancy is the presence of buttons, which are now large enough to palpate. In a 3-month pregnancy, they are flattened and egg-shaped and measure ¾ to 1 inch across. At this stage they are still rather soft to the touch, but they are firmer than the thin-walled uterus. The membranes are still filled tightly with fluid.

Stage II: 120 days until 6 months

At approximately 100 days, buttons become more apparent (1 to 1½ inches) and can usually be palpated. At this stage the fetus is still displaced similarly to the 90-day fetus. However, it has grown to approximately 10 to 12 inches long, with the head almost the size of a lemon. Often, the palpator can detect the head of the developing fetus before any other body part.

As the fetus enlarges and grows (now 4 to 6 months), its sheer weight displaces the entire reproductive tract deeper into the body cavity. This requires palpation deep in the body cavity (Fig. 14). All other characteristics have also changed. The buttons are more noticeable, since they have developed to about 2 to 2½ inches in length and have a much firmer feel. The pulsating uterine artery may be palpated (Fig. 13) and is now about the size of your little finger.

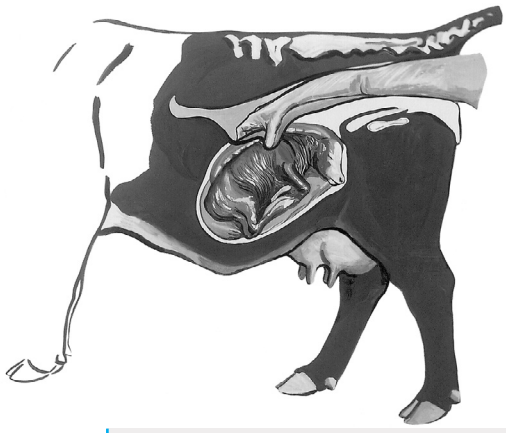

Figure 14. Enlarged calf now fills abdominal cavity at 5- to 6-month pregnancy stage.

Stage III: 7 months until 9 months

At 6 to 7 months, the fetus may or may not be deep in the body cavity (Fig. 14). Remember to reach deeply toward the stomach floor.

By 7 to 9 months, the fetus has grown to where it is often easy to palpate without reaching deeply. You can often feel the large bony structures (head, legs, and back). You may feel fetal movement. Occasionally in large bodied cows, the fetus may still be completely out of reach. To help confirm pregnancy, look for well-developed buttons or weight on the displaced cervix. You can also check the uterine arteries, which are now about the size of your thumb. The main change until parturition will be in size, as the fetus grows rapidly and uses more of the abdominal cavity. Table 5 summarizes outstanding identifying characteristics of pregnancy.

A WORD OF CAUTION

One word of caution is necessary to help avoid errors in determining pregnancy. The position of the reproductive tract on its own is not a reliable way to determine pregnancy. Many 90-day (and shorter) pregnancies may be located entirely in the pelvic cavity and not be displaced beyond the pelvic brim. On the other hand, pregnancies beyond 90 days are big enough that they most often are displaced beyond the pelvic brim. Conversely, some open tracts are not always located entirely within the pelvic cavity. In large-frame, fat cows, the open uteri may fall beyond the pelvic brim. In all cases, the tract must be adequately traced to correctly determine pregnancy status. Simply stated, the location of the tract should be used as a roadmap to lead the hand to the uterus, whether it is displaced beyond the pelvic brim or not.

TABLE 5. FETAL SIZE AND CHARACTERISTICS USED IN DETERMINING PREGNANCY.				
Stage	**Days of gestation**	**Fetal size**		**Identifying characteristics**
		Weight	**Length (inches)**	
I	30	1/100 oz.	2/5	One uterine horn slightly enlarged and thin; embryonic vesicle size of small marble. Uterus in approximate position of nonpregnant uterus. Fetal membranes may be slipped between fingers from 30 to 90 days.
	45	1/8 – 1/4 oz.	1 – 1 1/4	Uterine horn somewhat enlarged, thinner-walled and prominent. Embryonic vesicle size of small egg.
	60	1/4 – 1/2 oz.	2 1/2	Uterine horn 2½ to 3½" diameter; fluid filled. Fetus is the size of a mouse.
	90	3 – 6 oz.	5 – 6	Both uterine horns swollen *(4" to 5" in diameter)*. Fetus is the size of a rat. Uterine artery 1/8 to 3/16" in diameter. Cotyledons ¾" to 1" across, but very soft.
II	120	1 – 2 lb.	10 – 12	Similar to 90-day fetus more easily palpated. Fetus is the size of a small cat with a head the size of a lemon. Uterine artery ¼" in diameter. Cotyledons more noticeable and 1½" in length. Horns are 5" to 7" in diameter.
	150	5 – 8 lb.	12 – 16	Difficult to palpate fetus. Uterine horns are deep in the body cavity with fetus the size of a large cat—horns 6" to 8" in diameter. Uterine artery ¼" to 3/8" in diameter. Cotyledons 2" to 2½" in diameter.
III	180	10 – 16 lb.	20 – 24	Horns with fetus still out of reach. Fetus the size of a small dog. Uterine artery 3/8" to ½" in diameter. Cotyledons more enlarged. From sixth month until calving a movement of fetus may be elicited by grasping feet, legs, or nose.
	210 240 270	20 – 30 lb. 40 – 60 lb. 60 – 100 lb.	24 – 32 28 – 36 28 – 38	From 7 months until parturition, fetus may be felt. Age is largely determined by increase in fetal size. The uterine artery continues to increase in size—210 days, ½" in diameter; 240 days, ½" to 5/8" in diameter; 270 days, ½" to ¾" in diameter.

OTHER FACTORS

The paunch. Remember that the paunch (Fig. 6) is often encountered when entering the rectum and feeling beyond the pelvic brim and toward the left or very low in the body cavity. The shape of the dorsal and ventral sacs may be mistaken for the head or rear quarters of a calf. The difference can be determined by mashing on these large objects. The paunch will indent when mashed, while a well-developed calf may move away from the pressure of your touch. Also at these late stages of pregnancy, you can easily distinguish fetal features (ribs, hooves, and ears) when you touch them.

Kidneys. The kidneys (Fig. 6) are suspended directly under the spinal column at approximately a 30-degree downward angle. Because the left kidney in cattle is more toward the rear of the animal than the right one, it is often touched during palpation. The left kidney is elliptically shaped and is sometimes mistaken for a calf's nose. Practice helps you to distinguish the difference, but inexperienced palpators can avoid the left kidney by feeling at a steeper angle into the abdominal cavity. It is usually at this steep angle that large fetuses are located.

Buttons. Buttons may be mistaken for ovaries or vice versa. Buttons do not have the solid feel of an ovary but are rather soft. The best comparison is that they feel like dried apricots soaked in water. The ovaries are more rounded and egg-shaped with a firm feel. Only two are present.

Pyometra. In this condition, the uterus is filled with white blood cells attempting to clear up disease organisms. The uterus may be fluid to the touch or may be somewhat solidified, feeling rather plastic. This stage may be confused with early pregnancy stages if the uterus is in a fluid condition and only partly filled. In the latter stages of pyometra, the uterus becomes rather firm.

Large uteri. In older cows that have had many calves, the uterus may not return to its normal size, as it will in a younger cow. The enlarged uterus may be displaced over the brim of the pelvis as in a 3- to 4-month pregnancy. In an open cow, careful manipulation of the uterus will allow you to determine that no fluid and no developing buttons are present. Relaxation of the broad ligament tends to cause a similar condition.

Bladder. A full urinary bladder may be interpreted as a pregnancy in the 60- to 75-day stages. The full bladder feels similar to the uterus filled with fluid. Careful tracing should allow you to determine if the structure is the bladder, where there is only one body. This will also help you determine if the structure is a pregnant horn of the uterus, where both horns can be palpated and traced back to the cervix.

Enlarged cervix. Some Brahman and Brahman crossbred cattle have an enlarged cervix that is firm and feels like a developing fetus in its latter stages. You can distinguish between the two by tracing the reproductive tract.

Breed differences. Because of their large size, certain cattle breeds—Brahman crossbreeds, Santa Gertrudis, Charolais, Holstein and Brown Swiss—are more difficult to palpate in certain stages of pregnancy than the smaller European breeds. In the 3- to 4-month stages, the uterus may have dropped so deeply into the body cavity that it is almost impossible to palpate. In these cases, pass your hand under the cervix and lift the uterus to feel the fetus itself. By lifting the uterus and quickly moving your hand down into the body cavity, you can locate the fetus by gently bobbing the fluid and the fetus through the wall of the uterus.

Brahman and Charolais breeds appear to have more tissue inside than smaller breeds. More folds of the omentum seem to cover the intestines, making it slightly more difficult to pick up the uterus. Charolais cattle seem to have less flexibility in the rectum. It is commonly harder to feel deep into the body cavity in these cattle, and lateral movement is somewhat restricted. In Holstein cows, the anal sphincter may be tight. This limits the deep entry into the body cavity necessary to determine the stage of pregnancy. In these cases, proficiency at mid-uterine artery palpation may be necessary (Fig. 13).

The uteri of Brahman or Brahman-influenced heifers vary considerably. It is not uncommon to find 1,000-pound heifers with uteri measuring only 4 to 6 inches in length compared to a normal uterus (10 to 12 inches).

Highly finished cattle may be filled with fat which interferes with movement and feel. These cattle may be difficult to palpate. If you are uncertain, re-palpate at a later date.

SYSTEMATIC DETERMINATION

Once you understand the variations in location and size of the reproductive organs, your ability to determine pregnancy accurately depends upon a careful and logical check of the various reproductive and fetal structures. Using a systematic approach to checking each cow will ensure that you determine critical changes and variations in the location, size, and feel of the reproductive organs. A systematic approach not only helps ensure accuracy but also saves the palpator a lot of work. Figure 15 shows a systematic approach to determining pregnancy. While the system can be modified, it has proven to be a very functional approach for beginning and experienced palpators.

Figure 16 provides an outline of the important and critical factors that must be carefully checked and considered in determining the stage of pregnancy. If your pregnancy determination is to be accurate, you must consider all factors. The outline is basically an arbitrary division of pregnancy based upon the location of their reproductive organs and fetus. It is included to summarize the more important factors that indicate whether the cow is open or pregnant. Beginners should carefully study the outline and be familiar with the changes and variations that occur in each stage of pregnancy.

Even after following a systematic approach to palpation, some beginners will be unable to confirm pregnancy status on some cows. If this happens to you, simply wait 30 days and check these few again. If they are pregnant, their uteri will have grown which makes it easier to confirm their status. Never speculate on their status. Incorrect guesses can be costly.

Occasionally, cattle producers want an anticipated calving date (or known date of conception) for pregnancy records. The best way to determine this is by palpating in the early stages of pregnancy (90 to 100 days or less). These pregnancies are usually within the palpator's reach and are small enough to be sized. This allows a close estimate of anticipated calving date. In late pregnancies (120 days or more), fetal size can vary greatly among cows that actually conceived on or about the same day. Consequently, determining anticipated calving date (or day of conception) from records taken in late pregnancy is difficult and often inaccurate.

RECOMMENDATIONS

Practice! Experience is the key to palpation. In many instances, the ranch manager should not be the one to palpate but should supervise the operation and critically observe the cows. Unhealthy, unsound, and undesirable types should be eliminated—as should open cows.

Shorten the calving interval by reducing the time during the breeding season when the bulls are with the cows. Cows that settle first are most adapted to reproduction. Wait about 90 days after the bulls are removed before you palpate. Most cows should conceive at the beginning of the season, and only a few will be short-term pregnancies. Cull as critically as is feasible for your operation. If every open, unsound cow can be removed, cull immediately.

Remember, palpation is an art and a skill. It pays dividends to the person who uses it wisely.

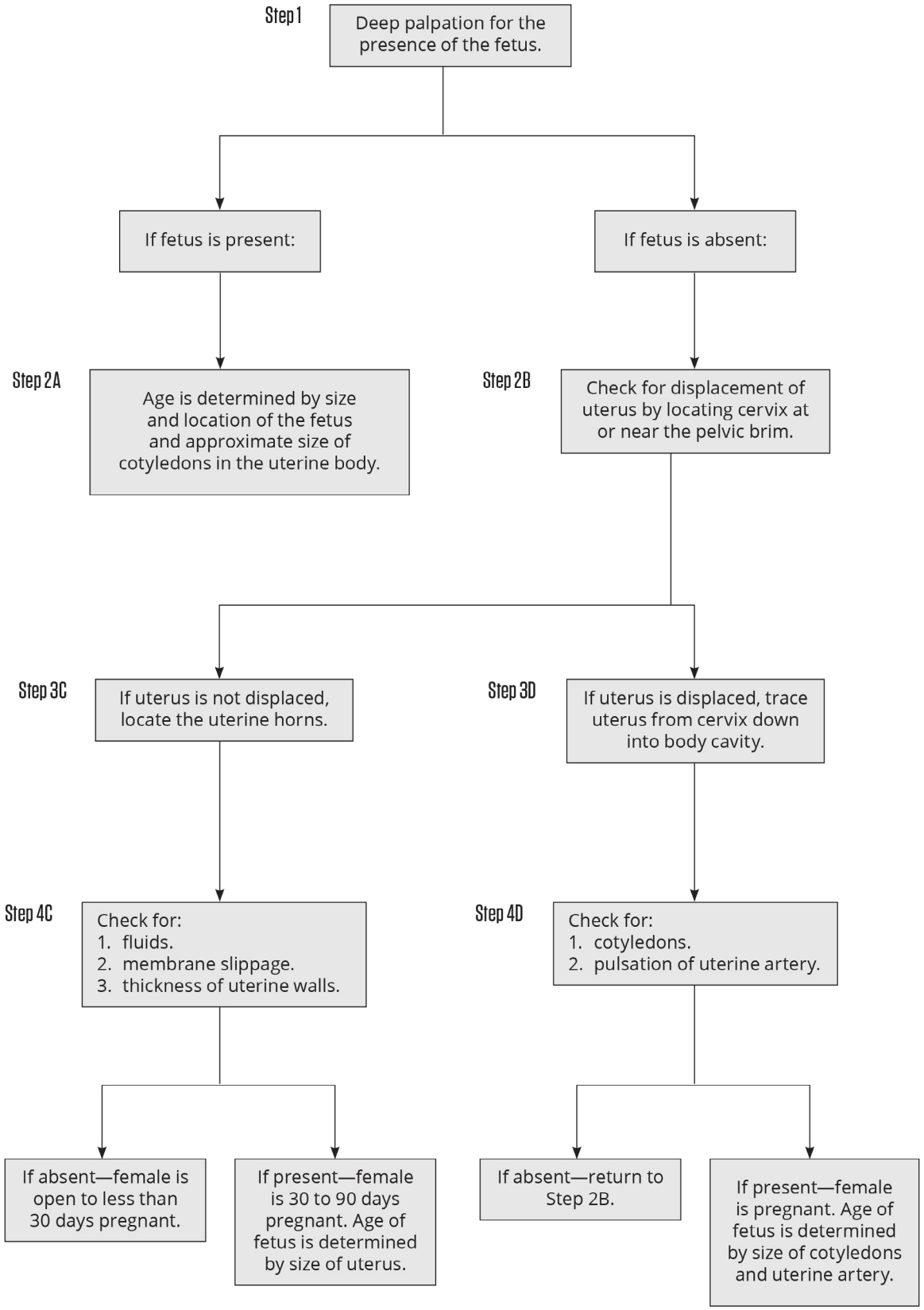

Figure 15. A systematic approach to pregnancy determination in the cow.

OTHER METHODS FOR DETERMINING PREGNANCY IN CATTLE

Ultrasound

Trans-rectal ultrasonography has many uses for reproductive diagnostics in cattle, including pregnancy determination. However, using it as a method for routine pregnancy determination on animals in late Stage I or in Stages II or III of gestation, probably does not have advantages over other methods. There are situations where ultrasound might be the best way to examine the uterus or conceptus including early pregnancy determination, fetal sexing, or determining the number and viability of the conceptuses.

When performing a trans-rectal ultrasound examination, a trained person places a transducer probe in the rectum of the cow. The "arm in method" uses the same hand to hold the transducer and to manipulate the uterus within the rectum. The "arm

Open cows

In females that are nonpregnant or open, the entire reproductive tract is usually located within the pelvic cavity. In older cows and large-frame cows however, the cervix and uterine horns may be distended over the pelvic brim into the body cavity.

Determing Factors:

1. No fluids in uterus
2. No membranes present upon slippage
3. Thick uterine wall with meaty texture
4. Uterine tone
   a. Firm – at or near estrus
   b. Flaccid – between estrous periods

Stage I Pregnancy

Females in this stage vary from 40 days to 3 months of pregnancy. The cervix and uterine horns are in the pelvic cavity or perhaps moving over the pelvic brim into the body cavity as Stage I advances.

Determing Factors:

1. Fluids in uterus and somewhat enlarged
2. Presence of membranes upon slippage
3. Thin uterine walls
4. Buttons indistinct to touch

Stage II Pregnancy

Determing Factors:

1. Displacement of uterus
2. Presence of buttons
3. Pulsation of middle artery

(Any two factors are considered sufficient evidence.)

Stage III Pregnancy

Females in this stage vary from 5½ months pregnant to term. The cervix is at or near the pelvic brim. The developing calf has achieved sufficient size to be reached in palpation. Palpation of the calf becomes progressively easier as Stage III advances.

Determing Factors:

1. Displacement of uterus
2. Palpation of large fetus
3. Presence of buttons

Figure 16. Factors that must be considered in determining pregnancy at different stages of gestation.

free method" uses an extender to place the transducer into the rectum and to manipulate it there. With either method, the transducer sends and receives sound waves that have been directed along the uterine horns. Since tissues and fluid will reflect and absorb sound waves differently, those sound waves are transduced into an electronic image. This is then viewed on a special monitor. Skill is needed to manipulate the probe and interpret the image produced on the monitor (Fig. 17). Pregnancy may be detected as early as 26 to 28 days, but examinations will be more accurate if they are preformed after 30 days.

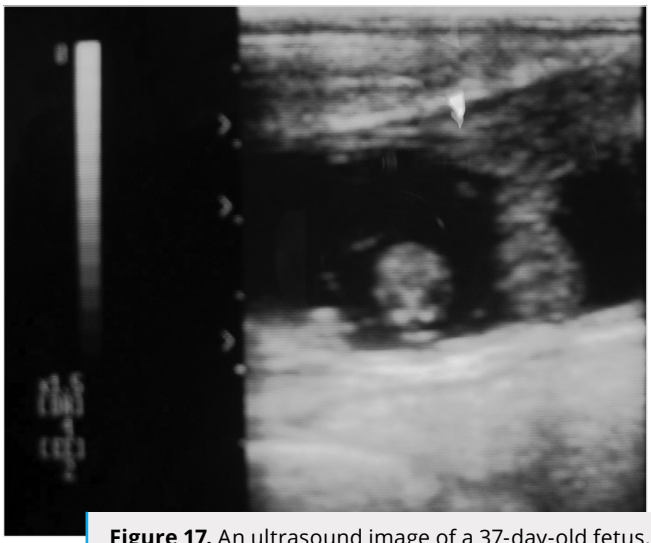

Figure 17. An ultrasound image of a 37-day-old fetus.

Blood Test for Pregnancy Associated Glycoproteins

Pregnancy associated glycoproteins (PAGs) or pregnancy specific protein B (PSPB) were identified by researchers looking for pregnancy specific markers that could be used for pregnancy diagnosis in cattle. While PAGs have proven to be a reliable marker for pregnancy, their physiological role is unknown. Produced by binucleate trophoblast cells of the placenta, PAGs enter the maternal circulation as early as day 22 to 24 and reach levels currently acceptable for accurate pregnancy diagnosis at day 28 of gestation.

Pregnancy specific protein B or PAG-1 was the first identified member of the PAG family, which encompass more than 20 individual proteins and 2 dozen genes. The discovery of PAG-1 led to the development of a radioimmunoassay for PAG detection and the validating study concluded that PAGs were only secreted into the maternal system of pregnant animals. Some commercial PAG-based pregnancy diagnostic tests still utilize PAG-1 as a target PAG. In 2005, an enzyme-linked immunosorbent assay (ELISA) specifically targeted PAGs secreted early in gestation that had a shorter half-life (4.3 days compared to 8.4 days) than the previous targets. These PAGs reduce the potential for false positives in postpartum cows. The ELISA was demonstrated to identify pregnant or non-pregnant cows via PAGs at day 28 post insemination. Studies comparing the efficacy of the PAG ELISA, PAG RIA and transrectal ultrasonography revealed comparable results for the diagnosis of pregnancy in cattle at day 28 of gestation—although some differences were identified in the ability of certain assays to detect non-pregnant animals. Today, commercial PAG testing is extremely accurate, providing 98 to 99 percent true positive (pregnant) reading and between 1 and 5 percent false positive rates (reported as pregnant but actually non-pregnant). However, some false positives may be due to embryonic mortality or even sample labeling error. Tests currently available include BioPRYN (BioTracking LLC. Moscow, ID USA; *https://biopryn.com*), IDEXX Bovine pregnancy test (IDEXX Laboratories Inc. Westbrook, ME USA; www.idexx.com) and DG29 pregnancy test (Genex Cooperative Inc. Shawano, WI USA; *https://genex.coop*). BioPRYN accepts blood samples from heifers 25 days post breeding and cows 28 days post breeding; IDEXX recommends day 28 blood or milk samples; and DG29 has been validated using day 29 blood samples. Each test mentioned above has a recommended number of days post-calving prior to submitting a sample. These recommendations are in place to prevent PAG from the previous pregnancy resulting in a false positive for the current sample. If calving dates are unknown, sample the cow herd 28 (29) days (or more) after the end of the breeding season or take two samples 28 days apart during the middle of the breeding season. It is critical to follow these recommendations closely to maximize the accuracy of the tests. Sample collections for all commercial tests mentioned above are shipped by commercial carrier to a laboratory. Results are available by e-mail, fax, or telephone within 24 to 72 hours after arrival at the lab. Currently, there is no chute side test available. However, IDEXX offers the rapid visual test, which is designed for an on-farm or in-clinic setting with results in 21 minutes. Cost of all commercial tests range between $2.25 to $5.00 per sample plus the purchase of blood collection equipment and shipping.

When comparing chemical-based pregnancy testing to rectal palpation or ultrasound, note that the results of these test are not immediately available. Any keep or cull decisions would be post-poned until receipt of the lab report or on-farm testing is complete. In addition, cattle must be individually identified to allow for culling or other management once the results of the test are known. With the other two methods, neither individual ID nor the need to re-work cattle is required. Also, a skilled person can determine the stage of preg-

nancy (Stage I, II or III) with either rectal palpation or ultrasound. This type of information may be useful for culling and marketing decisions or in determining if conception may have occurred unintentionally after the end of a breeding season.

There are a few benefits to consider when evaluating the use of blood-based pregnancy testing in cattle. One major benefit to consider is the lack of prior planning needed to conduct the sample collection. For example, in both rectal palpation and ultrasound a veterinarian or skilled technician needs to be present on the day of the cow-working. However, with chemical based testing only an individual who can effectively collect the sample, label the tube, and prepare the shipment is needed. Additionally, research conducted at Texas A&M suggests potential for pregnancy detection earlier in gestation and the potential for determining embryonic and fetal loss. While PAG testing is confined to the time period of physiological availability (not before day 24), a recent study in heifers undergoing embryo transfer have shown potential for a day 24 pregnancy test. Thus, early pregnancy diagnosis using PAG is possible. However, more work is needed in this area to refine methods and detection assays. The ability to predict and detect pregnancy loss or failure is the next frontier in pregnancy diagnosis. Data generated using PAG assays suggest that embryo loss can be predicted using these specific PAG assays. Recent PAG testing studies have shown a strong correlation between successful pregnancies and elevated serum PAG concentrations early in gestation. In comparison to progesterone concentrations—which exhibit no difference between heifers or cows that undergo embryo mortality and those that maintain pregnancy—PAG concentrations are significantly different between the two groups. Cows that maintained pregnancy had significantly higher serum PAG concentration than cows that underwent pregnancy loss after a viable embryonic heartbeat was detected at day 28.

Figure 18. Bleeding by tail venipuncture.

PAG testing can also be used in artificial insemination (AI) programs for first-calf heifers to determine conception to AI compared to clean-up bulls. It is critical to wait at least 10 days after the last day of AI before placing clean-up bulls with the heifers. Blood testing all heifers at day 28 (up to day 36) after the last day of AI will detect AI pregnancies, but not early pregnancies from bulls. All heifers reported as "open" will be retested 28 days or more after the end of the bull breeding season.

TABLE 6. ADVANTAGES AND DISADVANTAGES FOR THREE METHODS OF PREGNANCY TESTING.

	When pregnancy can be detected	Age of calf	Sex of calf	Experienced technician needed?	Cost/Cow	When results known
Palpation	35–50 days	Yes	No	Yes	$3–$10	Immediately
Ultrasound	30 days	Yes	Potentially	Yes	$7–$15	Immediately
Blood Test *(PAG)*	28–30 days	No	No	No	$3–$5	1–4 days

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