

# REPRODUCTIVE MANAGEMENT STRATEGIES TO MAXIMIZE PRODUCTION WITH NATURAL SERVICE

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## Introduction

Approximately 77% of cow-calf operations are commercial, 6% are seedstock and 17% are a combination of commercial and seedstock (NAHMS, 2020). Overall, natural service is the most common strategy to generate pregnancies, as 90.7% of all females were exposed only to bulls (NAHMS, 2020).

Overall adoption of reproductive technology is low, as evidenced by only 37.5% of operations using at least one technology. Slightly greater than 7% of producers employ estrous synchronization, 11.6% use artificial insemination (AI), and less than 67% have the semen of purchased, leased, or borrowed natural service bulls evaluated (NAHMS, 2020). When also considering bulls in residence, overall, less than 20% of producers have semen of natural service bulls evaluated (NAHMS, 2020).

There are many advantages to the use of AI for the beef producer, including access to semen from genetically superior bulls, the reduction of bull purchase, leasing, and maintenance costs, and increased safety of family and employees.

The majority of U.S. producers (58.7%) do not have a defined breeding season (NAHMS, 2020), leading to calves being born throughout the year, resulting in a lack of uniformity in the calf crop. Breeding strategies using natural service and estrus synchronization, however, offer the producer the opportunity to implement distinct breeding and calving seasons, shifting pregnancy initiation and calving to earlier in each season, resulting in greater weaning weights (Larson et al., 2010). Further, heifers that calve earlier have greater herd longevity and produce more pounds of calf during their lifetime than heifers calving later (Cushman et al., 2013).

## Bull Breeding Soundness Evaluation

A breeding soundness evaluation (BSE) is a critical management strategy to ensure optimal health and promotion of fertility. A BSE should be performed on all natural service bulls: 1) prior to purchase, 2) annually, and 3) whenever there is concern relative to the potential fertility of a bull. Comprehensive guidelines for the BSE were updated by the Society for Theriogenology in 2018 (Koziol and Armstrong, 2018).

The BSE is a comprehensive assessment and consists of three sections:

**1) Physical examination.** For natural service to be successful, bulls must be able to identify cows in heat and copulate. Consequently, the BSE begins with a physical examination of the bull, with particular importance paid to the soundness of eyes, feet and legs. Vision plays a key role in identifying potentially receptive females (Geary and Reeves, 1992). In order for copulation to occur, the bull must be able to physically support a substantial portion of his weight on his rear legs, fully extend his penis, and gain adequate intromission to deliver the ejaculate. Bulls with sore feet, legs or back, or with traumatic injuries, may not adequately or efficiently service cows. In addition, bulls with poor conformation (post-legged or sickle-hocked) have an increased risk of lameness compared with bulls of proper conformation. The BSE also includes examining the testes, epididymides, penis, and prepuce, as well as internal organs (seminal vesicles, prostate, and ampullae).

**2) Scrotal circumference.** Scrotal circumference is a measure of testicular volume and is highly correlated to sperm production, especially in young bulls (Willet and Ohms, 1957; Hahn et al., 1969). Consequently, bulls with insufficient scrotal circumference (relative to age) may not efficiently generate pregnancies. Increased scrotal circumference is associated with decreased age at puberty in related females (Brinks et al., 1978). An earlier age at puberty for beef heifers is associated with increased lifetime fertility and pounds of calf produced (Brinks, 1994). Veterinarians and producers must also realize, however, that scrotal circumference is of less value as an indicator of sperm production in bulls greater than 5 years of age, as there is a reduction in sperm output per gram of testis in old bulls (Hahn et al., 1969).

**3) Semen collection and evaluation.** Following collection of a semen sample (usually by electroejaculation), sperm motility and morphology are evaluated. In general, fertile bulls have a greater percentage of progressively motile sperm and a lower percentage of morphologically abnormal sperm than sub-fertile or infertile bulls (Williams and Savage, 1925; Lagerlof, 1934; Saacke, 1982; Barth and Oko, 1989).

Based on data resulting from a BSE, bulls may be classified as: 1) a satisfactory potential breeder, 2) an unsatisfactory potential breeder, or 3) classification deferred. A bull must meet minimum criteria for scrotal circumference, sperm motility and morphology to be classified as a satisfactory potential breeder. These bulls must also be free of other problems (feet, legs, eyes, penile, preputial, accessory sex glands) that may reduce fertility in natural mating situations.

The classification of a bull as a satisfactory potential breeder *does not guarantee* the bull is currently a satisfactory breeder, or that the bull will be a satisfactory breeder in the future. The BSE outlines minimum standards that must be achieved, in addition to passing a physical exam. A BSE does not evaluate a bull's libido, a highly desirable and measurable trait. Libido is most often evaluated through the use of serving capacity tests that evaluate the number of services attempted by bulls during a limited period of time using restrained, non-estrous cows at predetermined bull to cow ratios (Blockey, 1976).

Bulls with physical abnormalities, and (or) those bulls not meeting the required minimum standards should be classified as an unsatisfactory potential breeder. Classification may be deferred

at the discretion of the veterinarian for bulls that cannot be classified as satisfactory but may improve with time. This category includes young bulls with immature ejaculates and any bull with unacceptable sperm motility and morphology, considered to be temporary, and capable of improving. Sperm production (spermatogenesis) in the bull is a continuous, dynamic process that takes 61 days to complete. Consequently, physiologically stressful events (e.g., illness or environmental heat stress) may affect sperm motility and morphology for nearly two months after the event. Therefore, bulls that receive a “classification deferred” status on a BSE (due to poor sperm motility and morphology) should be re-tested in 60 days.

The importance of using BSE’s cannot be overemphasized. In 2018, Roberts reported 82% of beef bulls from 2,883 BSE’s conducted over 10 years (2007-2017) were classified as satisfactory potential breeders, with 15% deferred and 3% unsatisfactory. Carson and Wenzel (1995) evaluated 1,276 beef and dairy bulls and reported 37.1% received unsatisfactory (28.9%) or deferred (8.2%) classification. The main reasons cited for unsatisfactory or deferred classification were unacceptable sperm morphology, insufficient scrotal circumference, and physical problems, including eye lesions, lameness, and internal and external sex organ lesions (Carson and Wenzel, 1995). This gives evidence of the superiority of the BSE as compared to semen testing for the evaluation of breeding soundness.

Menegassi et al. (2011) reported a benefit to cost ratio of \$19.67 for each \$1 invested in the BSE. Similarly, Chenoweth (2002) argued a benefit to cost ratio of \$20.00 for each \$1 invested in the BSE. Using these values as a starting point, the BSE is clearly a prudent, yet underappreciated and underutilized economic tool.

### **Estrous Synchronization and Natural Service**

Estrous synchronization is a management strategy designed to physiologically manipulate heifers and(or) cows to induce them to exhibit standing estrus in a defined period of time. In general, estrous synchronization strategies significantly reduce the number of days needed to detect a group of animals in standing estrus and allows for more females to conceive early in the breeding season. More specifically, estrous synchronization provides two chances to conceive within the first month of the breeding season.

### **Selection of a Protocol for use with Natural Service**

Recommended protocols for use with natural service are shown in Figure 1. Unlike synchronization and AI (where the goal is to have the maximum number of females in estrus in the shortest period of time), producers implementing synchronization and natural service must consider the limitations of natural service (serving capacity of the bull). Thus, protocols that distribute estrus over a period of 7 to 14 days are more advantageous. Therefore, it is necessary to understand how different synchronization products work with the physiology of the estrous cycle.

Prostaglandin  $F_{2\alpha}$  (PG) regresses the corpus luteum (CL), allowing cows and heifers to return to standing estrus (Lauderdale, 1972; Rowson et al., 1972; Tervit et al., 1973) sooner than if the animals were not synchronized. During the first five days after an animal exhibits estrus, the CL

is not responsive to PG (Lauderdale, 1972; Rowson et al., 1972), but when PG is administered between day 5 to 17, the CL will regress and the animal will usually exhibit standing estrus within 120 hours (Lauderdale et al., 1974). If a heifer or a cow does not have a CL (e.g., postpartum anestrus cows or prepubertal heifers), the animals will not respond to PG treatment. Thus, animals must be cycling, and between days 5 and 17 of the estrous cycle to respond to PG.

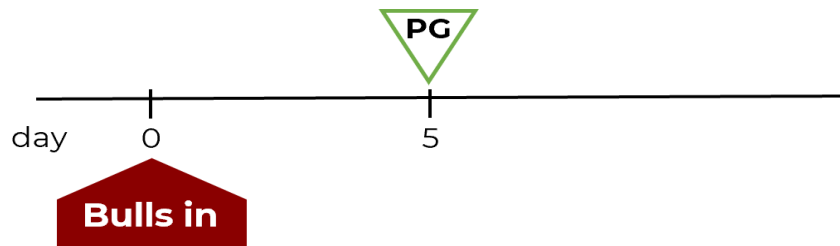
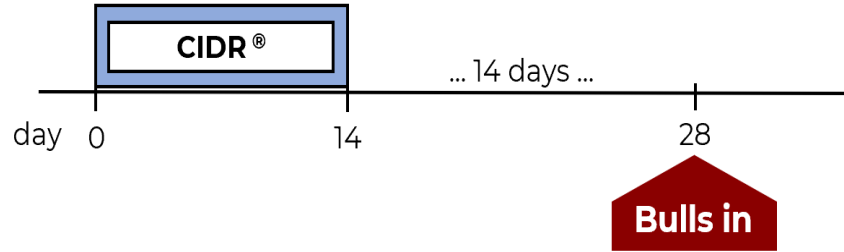
Progestins (including exogenous progesterone and melengestrol acetate, MGA) which mimic progesterone produced by the CL to inhibit estrus and ovulation, are an effective method of synchronizing cattle (Odde, 1990) by extending the luteal phase of the estrous cycle. After removal of the progestin, progesterone concentrations decrease, and standing estrus and ovulation will occur. A negative effect of synchronization with a progestin, however, is when a CL regresses and cows or heifers are exposed to a progestin to inhibit ovulation of the dominant follicle. In this scenario the dominant follicle continues to grow and becomes a persistent follicle. Breeding animals at the first estrus after progestin exposure for more than seven days resulted in decreased fertility (Mihm et al., 1994; Ahmad et al., 1995) but subsequent ovulations had normal fertility (Odde, 1990).

When a controlled internal drug releasing insert (CIDR) containing progesterone was inserted seven days before the start of the breeding season and removed the day the bull was introduced (no injections), more CIDR-treated cows (43%) became pregnant by day 10 compared to non-synchronized cows (35%; Table 1; Lamb et al., 2008). However, when a single injection of PG was administered to a group of anestrus cows, no difference was detected between synchronized and non-synchronized cows (13.6% and 22.7%, respectively; Table 1; Whittier et al., 1991). Therefore, progestin-based estrous synchronization protocols capable of shortening the postpartum anestrus period can result in a greater percentage of cows having a chance to become pregnant during the first few days of the breeding season.

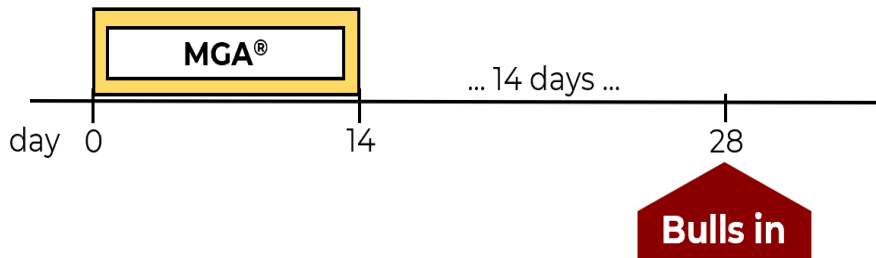
Unfortunately, not all progestins are equally effective at inducing estrous cycles in postpartum anestrus cows. Fewer anestrus cows treated with MGA (0.5 mg MGA per cow per day for 7 days) ovulated compared to progesterone-treated cows (CIDR containing 1.9 g of progesterone for 6 days; 33% and 91%, respectively; Perry et al., 2004). Furthermore, fewer control (cows that spontaneously initiated estrous cycles; 23%) and MGA-treated anestrus cows (46%) exhibited normal length luteal phases compared to progesterone-treated cows (100%) (Smith et al., 1987; Perry et al., 2004). By day 22 after treatment withdrawal, however, there was no difference between the percentage of CIDR-treated cows that had ovulated (91%) and the percentage of MGA-treated cows that had ovulated (61%; Perry et al., 2004).

Referring to Figure 1, a single injection of PG on day 5 of the breeding season resulted in more cycling cows becoming pregnant between days 5 to 9 of the breeding season compared to cycling cows not treated with PG (55.7% vs. 25.0% respectively; Table 1; Whittier et al., 1991). These results provide evidence of the greatest benefit of estrous synchronization, i.e., the ability to increase pregnancy rates early in the breeding season (Table 1), resulting in an increased number of calves born at the start of the calving season.

## COWS & HEIFERS



## HEIFERS ONLY



**Figure 1:** Recommended protocols for synchronizing cows and heifers to be bred by natural service.

**Table 1.** Comparison between synchronized and non-synchronized pregnancy rates of cows and heifers bred by natural service

Study	Period of bull exposure	Cows or heifers	Synchronization method	Cycling Status and Pregnancy Rate		
				Anestrual	Unknown	Estrual
Whittier et al. (1991)	4 days	Cows	1 shot PG	13.6%		55.7% <sup>a</sup>
			Not synchronized	22.7%		25.0% <sup>b</sup>
Lamb et al. (2008)	10 days	Cows	CIDR		43% <sup>a</sup>	
			Not synchronized		35% <sup>c</sup>	
Landivar et al. (1985)	80 hours	Cows	1 shot PG		19%	
	21 days		Not synchronized		33%	
Whittier et al. (1991)	25 days	Cows	1 shot PG		59.1%	
	21 days		Not synchronized		59.1%	
Lamb et al. (2008)	30 days	Cows	CIDR	64.4%		86.1%
			Not synchronized	64.7%		76.3%
Locke et al. (2020)	21 days	Heifers	14-day CIDR	52%		55%
			14-day MGA	53%		59%
Locke et al. (2020)	61 days	Heifers	14-day CIDR	57%		80%
			14-day MGA	66%		90%

Pregnancy rates within a study and estrous cycling status having different superscripts are different <sup>ab</sup> $P < 0.01$ ; <sup>ac</sup> $P < 0.05$

In another study, a CIDR was inserted for seven days (no injections were given; Figure 1). Bulls were introduced immediately following CIDR removal (Figure 1; Lamb et al., 2008). The use of a CIDR to synchronize with natural service decreased the average days to conception and increased the percentage of animals that conceived in the first 10 days of the breeding season (35.9% vs 30.8%, Lamb et al., 2008).

### Bull to Female Ratio

Briefly, recommendations for the bull to female ratio in non-synchronized cattle is 1:10 to 1:60 (Perry et al., 2010). This range in the bull to female ratio depends on the age, experience, libido, and semen quality of the bull (Perry et al., 2010). The terrain and size of the breeding pasture must also be considered. Rupp et al. (1977) reported no differences in pregnancy rates between a bull to female ratio of 1:25 and 1:60 in the first 21 days of the breeding season provided the bulls were highly fertile and had a large scrotal circumference.

Management must consider the serving capacity of a bull when using natural service with synchronized females. Healy et al. (1993) used experienced bulls 2 to 5 years of age and reported reduced pregnancy rates over a 28-day breeding season when a bull to synchronized female ratio of 1:50 (77%) was used compared to 1:16 (84%; Table 2). No difference was reported between a bull to synchronized female ratio of 1:16 (84%) and 1:25 (83%; Table 2; Healy et al., 1993). Net revenue per heifer exposed, however, was optimized at a bull to heifer ratio of 1:25 (Table 2; Healy et al., 1993).

**Table 2.** Bull to heifer ratio, pregnancy rate, and net revenue per heifer exposed (Healy et al.,1993)

	Bull to heifer ratio		
	1:50	1:25	1:16
Bulls in pasture, n	2	4	6
Heifers in pasture, n	100	100	100
28 d pregnancy rate, %	77.0 <sup>a</sup>	83.0	84.0 <sup>b</sup>
Net revenue per heifer exposed	\$955	\$973	\$965

<sup>a,b</sup>Values within a row with different superscripts differ ( $P < 0.05$ ).

A reasonable recommendation of a bull to female ratio is 1:25. It is important to remember, however, that young bulls should be used at a lower bull to female ratio than older bulls. NAHMS (2020) data provides evidence that the average number of females per bull varies by herd size and age of the bull (Table 3).

**Table 3.** Average number of females expected to be serviced per bull, by bull type and herd size (NAHMS, 2020)

	Herd Size			
	Small (1-49)	Medium (50-199)	Large (200 +)	All
Yearling < 2 yr. of age, %	13.9	16.9	19.8	15.2
Mature > 2 yr. of age, %	20.3	26.5	27.7	22.0

Monitoring bulls during the breeding season is particularly important, as poor performance of a bull in a single-sire breeding group will affect the number of calves born from that group. In multiple sire breeding pastures, it is difficult to identify the sire of calves. For example, Van Eenennaam et al. (2007) investigated the paternity of 625 calves that resulted from a multiple sire ( $n = 27$ ) breeding pasture. Following DNA analysis, Van Eenennaam et al. (2007) reported 5 of 27 sires produced over 50% of the calves. Further complicating the issue was the reality that 10 sires produced no progeny (9 of which were yearling bulls). Following genotyping, Abell et al. (2017) also reported major differences existed between bulls siring the greatest and least number of calves in a study with 179 bulls and over 3,700 calves. The majority of U.S. beef operations, however, do not conduct DNA testing for sire identification of calves (Table 4).

**Table 4.** Percentage of U.S. beef operations that used commercially available DNA testing for sire identification of calves (NAHMS, 2020)

	Herd Size			
	Small (1-49)	Medium (50-199)	Large (200 +)	All
Yes, %	2.6	5.6	10.6	3.6
N/A (Only 1 bull), %	20.8	8.8	1.4	17.3
No, %	76.6	85.6	88.0	79.0
Total	100.0	100.0	100.0	100.0

Lehrer et al. (1977) reported similar results to Van Eenennaam et al. (2007) when studying multiple sire breeding groups. Reasons for the variability in the number of calves born per bull in multiple sire groups may be related to libido, social dominance, and fertility differences among bulls (Whitworth et al., 2008; Smith et al., 1981).

Social rankings are related to age and size, and a bull's rank may influence the number of females a sire is willing or able to breed (Table 5). Thus, special attention should be paid to sires that have decreased semen quality (borderline motility and morphology) and small scrotal circumference but appear to be socially dominant. These bulls could prevent a more fertile, but less dominant bull from breeding females. A bull's seniority is the major factor influencing his social ranking, with the dominant bull in a breeding cadre likely being an older bull (Chenoweth, 1997). When bulls (1 to 7 years of age) were used at a ratio of 1:7 to 1:51, yearling bulls had the lowest pregnancy rates (30.2%, based on number of females exhibiting estrus) compared to 2-yr old (40.3%) and mature bulls (3 years and older; 50.7%), even though pregnancy rate was not affected by bull to female ratio or number of females exhibiting estrus (Pexton et al., 1990).

Producers should avoid placing young and older bulls in the same multiple sire pasture. If multiple sire groups are necessary with bulls of mixed ages, bulls may be grouped together before the breeding season to allow for social hierarchy to form before interaction with females. If at all possible, it is advantageous to separate cows into single sire groups, or smaller multiple sire groups.

**Table 5.** Percentage calf crop sired by individual sires in multiple sire pasture (Lehrer et al., 1977)

Social Rank	Percentage Calf Crop Sired				
	Pasture 1	Pasture 2	Pasture 3	Pasture 4	Pasture 5
Bull 1	30%	34%	44%	92%	75%
Bull 2	21%	29%	18%	3%	25%
Bull 3	12%	21%	16%	3%	0%
Bull 4	10%	6%	4%		
Bull 5	9%	4%	4%		
Bull 6	9%	1%	4%		
Bull 7	5%	1%	2%		
Bull 8			2%		
Bull 9			2%		
Bull 10			0%		
Number of calves born	73	64	43	28	32

In multiple-sire breeding groups, bulls tend to breed or try to breed the same sexually responsive females (Farin et al., 1982). This can lead to females being bred by more than one bull and increases the risk of injury to a bull. When multiple cows or heifers are in estrus at the same time, they form a sexually active group. This grouping together increases the ability of a dominant (but possibly less fertile) bull to keep subordinate bulls from breeding cows. When single- versus



multiple-sire use was compared in synchronized beef heifers (1:20 vs 2:40), mating performance of bulls and pregnancy rates were not different, but heifers in single-sire herds were serviced more times than those in multiple-sire herds (4.1 vs 2.6, respectively; Farin et al., 1982). In another study pregnancy rates increased when females were serviced two or more times compared to females only serviced once (Pexton et al., 1990).

### **Estrous Detection and Libido**

For successful insemination of cattle to occur, animals must be detected in standing estrus. Detecting standing estrus (also referred to as heat detection or detecting standing heat) is simply looking for the changes in animal behavior associated with a cow or heifer standing to be mounted by a bull or another cow or heifer. With natural service, estrous detection is often considered to be easy, as it is “the bull’s job.” However, differences in estrous detection exist among bulls. Libido refers to a bull’s desire to mate. Libido is thought to be a moderately inherited trait (Chenoweth, 1981; Blockey, 1989; Boyd et al., 1989) with heritability ranging as high as 0.59 (Blockey, 1989). This is because there is more variation in libido between sons of different sires than between sons of the same sire. It is important to remember that scrotal circumference, semen quality, and physical conformation (all important aspects of the Breeding Soundness Evaluation) are not related to libido (Blockey, 1975; Chenoweth et al., 1977), but libido has a direct effect on pregnancy rate and, as such, can influence the success of an entire breeding season. In the absence of a libido test (described earlier in this paper), libido can be practically evaluated by closely watching a bull after introduction to a herd and determining his desire to detect cows and(or) heifers in estrus.

### **Summary**

Reproductive management strategies to maximize production with natural service include a BSE for all bulls, and estrous synchronization. A BSE is critical to ensure optimal health and promotion of fertility. For a bull to be classified as a satisfactory potential breeder, the bull must be free of problems that reduce fertility in natural mating situations, and meet minimum criteria for scrotal circumference, sperm motility and morphology. Estrous synchronization allows for more females to conceive early in the breeding season and gives females that do not conceive to first service an opportunity for a second service within the first 30 days of the breeding season. A protocol that distributes estrus over 7 to 14 days is advantageous. With synchronized females, it is important to remember that mature bulls ( $\geq 3$  years old) have increased efficiency in getting cows pregnant compared to younger bulls. Producers must also recognize the impact of social hierarchy on the success of bulls in multi-sire pastures, where research has shown a dominant bull may sire a disproportionate number of calves. Previous research (using bulls aged 2 to 5 years) provides evidence that net revenue per synchronized heifer exposed was optimized at a bull to heifer ratio of 1:25. It is important to remember, however, that young bulls should be used at a lower bull to female ratio than older bulls.

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