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Beyond Bull Breeding Soundness Evaluations (BSEs)

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Introduction

The capability of bulls to distribute their genetics is dependant upon their fertility, whether they are used for natural breeding or A.I. In turn, herd reproductive performance has been shown to have a greater impact on economic returns than either growth rate or product quality (Wiltbank 1994). Here, chute-side math indicates it takes approximately 5 generations (15 years) using bulls of 10% superior WWT EPDs, to have the same impact on total herd lb weaned as a 5% increase (85-90%) in weaning rate.

Most cattle throughout the world are still bred naturally. However, breeding bulls differ markedly in their reproductive capabilities. Conservative estimates indicate at least 20% of unselected bulls are sub-fertile or infertile. Procedures used to evaluate bulls have been shown to be effective in identifying many of these sub-fertile and infertile bulls. The procedures involved in such evaluations are remarkably consistent throughout the world. In North America, the Society for Theriogenology (SFT) recommends a standardized procedure that has been periodically modified (Chenoweth et al, 1992).

Bull Selection & Purchase

Professional advice and input at the time of bull purchase can help to avoid a number of problems. However, such input appears to be underutilized. It is disappointing, for example to find only 15% of U.S. producers considered bull scrotal circumference was of great importance in bull selection, while 19% regarded it as being of no importance at all (USDA NAHMS 1994). Here, the major factors in bull selection were (in decreasing order from extremely important) breed, appearance/soundness and temperament. Paradoxically, in this same report, the most important bull culling criteria were infertility and physical unsoundness, while pre-purchase or pre-usage testing for Trichomoniasis was rare.

Bull Breeding Soundness Evaluation (BSE)

The Bull Breeding Soundness Evaluation represents a relatively quick and economic procedure to *screen bulls* prior to their sale or use. Its objective is to establish baselines, or thresholds, above which bulls would be regarded as *satisfactory potential breeders*. As it is intended for wide application with a variety of breeds in different environments, it needs to be simple, repeatable and unambiguous**.** *However, this should not imply the BSE should substitute for either professional judgment or common sense.*

Bulls are placed into categories of satisfactory, unsatisfactory and classification deferred. The system is most effective in identifying low-fertility, or sterile, bulls and it is relatively less effective in predicting individual bull performance at the upper end of the fertility spectrum.

Reasons for this include:

1. The BSE is a relatively quick and simple procedure, which does not attempt to comprehensively assess all aspects of male fertility.
2. Fertility is a complex trait which is influenced by both male and female traits as well as by extraneous factors.
3. The BSE aims to identify bulls which are ***satisfactory***.
4. Knowledge and understanding of male fertility keep increasing and changing.
5. This last factor, in particular, provides the impetus for the American Society for Theriogenology to periodically revise their recommended BSE procedures. The most recent revision (Chenoweth et al, 1992) is described below.

BSE Procedures.

The BSE usually includes the following steps:

1. Physical examination.
2. Reproductive examination (including measurement of scrotal circumference).
3. Collection and examination of semen.
4. Report

In addition, libido/serving capacity testing may be included, as may special tests for diseases (e.g. vibriosis or trichomoniasis). These procedures add predictive value to the assessment process and may be specifically indicated in some situations, but they are not part of the routine BSE. In addition to those described above, other limitations of the BSE include:

1. Results are most valid at the time of examination.
2. It does not attempt to predict fertility.
3. The system works best to identify infertile bulls

Timing of the BSE.

The best time to conduct a BSE varies with the reason for the test. For young bulls, the BSE is particularly advantageous prior to sale and first breeding. Here, the optimum time for evaluation would be as close to sale, or use, as possible, allowing adequate time for either retesting or replacement before breeding. *To allow for both considerations, it is common to schedule the initial BSE within 1 month of sale or introduction to the breeding herd.*

Young bulls must be pubertal for BSE classification. For infertility investigations and insurance exams, the test should be conducted as close as possible to the events in question. The time to allow before bulls are retested is also a consideration, as there are often time constraints. Here, professional judgment is necessary. For example, low sperm motility may be due to poor semen handling, increased numbers of accumulated sperm in the extra-gonadal system, or more serious problems. In the first two cases, improvement is often seen when a second ejaculate is collected within a few minutes of the first. If a bull is young and has increased “secondary” sperm defects (e.g. droplets and bent tails), evident improvement may occur within weeks, especially once bulls are taken off test. Over-conditioned bulls (particularly those which achieved rapid weight gains on a high grain diet) are often represented in this group. However, not all such bulls improve. More serious problems in the spermiogram may require 1-2 months for improvement, or they may never improve. A good policy is to schedule retests for 6-8 weeks, so possible differentiation may be made between temporary and more permanent problems.

General BSE Procedures. The primary mission of the natural breeding bull is to efficiently impregnate all available females as early in the breeding period as possible. To achieve this he must possess the physical and reproductive necessities to perform this task. These include good eyesight and musculoskeletal conformation as well as the necessary reproductive equipment and sex drive to produce and appropriately deliver sufficient numbers of fertile spermatozoa.

The final step of the BSE is to place bulls into one of three categories, viz:

- **Satisfactory:** These bulls equal or surpass the minimum thresholds for scrotal circumference, sperm motility, and sperm morphology and have no evident genetic, infectious, or other problems or faults that could compromise breeding or fertility.
- **Unsatisfactory:** These bulls are below one or more thresholds and are unlikely to improve. Also included are bulls that show genetic faults or irrevocable physical problems (including infectious disease) that would compromise breeding or fertility.
- **Classification Deferred:** Any bulls that do not fit into the above categories and could benefit from a retest. This category would include bulls with an "immature" semen profile* as well as any bulls whose semen is substandard but considered capable of improvement. Also in this category are bulls from whom a satisfactory ejaculate could not be obtained for reasons unknown as well as bulls with treatable problems such as seminal vesiculitis or footrot. In general, if any doubt exists about a bull fitting into either the satisfactory or unsatisfactory categories, he should be considered as a candidate for a retest and placed into the "classification deferred" category.

*It is not uncommon for yearling bulls to exhibit higher levels of certain types of sperm abnormalities associated with immaturity. Such bulls will usually require a second examination before being classified as a satisfactory potential breeder.

Red Flags

Bulls should not pass the BSE if any of the following are present:

- An heritable fault (eg umbilical hernia)
- One testicle (even if very large!)
- Frank pus in semen
- Active accessory genital disease (a.k.a. seminal vesiculitis)
- Significant loss of vision
- Positive test for either vibriosis or trichomoniasis
- Pronounced lameness

BSE Utilization

The BSE, in various forms, has been in use for at least 50 years. However, surveys in the US indicate its use with sale bulls is static, and prone to go down when cattle prices drop. Particularly disappointing is the number of herd bulls tested prior to each breeding season. More encouraging is the trend for larger operations and those which derive most or all income from cattle, to have relatively high adoption rates

For producers to more readily adopt the BSE, they require assurance in the following areas:

► **the procedure is not too disruptive or difficult to implement**
► **results are credible and unambiguous**
► **there are positive cost-benefits**

The first two items on this list relate to aspects of equipment, technique and interpretation. Examples of poor procedures which can reduce the validity of results, as well as producer acceptance, include:

- Poor microscope quality and maintenance
- Poor preparation of semen stains/smears
- Use of inadequate magnification for good sperm morphology assessment
- "Rough" and inappropriate electro-ejaculation technique
- Poor scrotal circumference measuring technique

Cost-Benefits of Bull Evaluation.

Bulls vary in their reproductive capabilities. Although it may be relatively simple to recognize a sterile bull, identifying sub-fertile bulls is more difficult, especially in multi-sire breeding herds. Use of the BSE allows bulls to be categorized reasonably accurately. For example, several trials have used bulls with groups of estrus synchronized heifers to increase breeding pressures. In one such study, bulls classified as satisfactory using the BSE, obtained 10.5% more pregnancies than those categorized as questionable. In a similar study, satisfactory bulls obtained a pregnancy rate advantage of 6% over the synchronized breeding period, and 9% ($P<0.10$) for the entire breeding season, when compared with questionable bulls. Another approach has determined bull fertility from calf parentage in multi-sire herds. In one such study, the most important bull factors for herd fertility included large scrotal circumference and low numbers of sperm defects. In another, prior BSE screening of bulls in a large herd increased pregnancies (3.5%) while using 40% less bulls over a shortened breeding period. An Australian study employing DNA parentage (Holroyd et al 1998), as below, concluded "semen quality, particularly percent normal spermatozoa, was consistently related to calf output". In summation; "these results confirm that semen examination, including sperm morphology, should be standard procedure when assessing bulls for reproductive soundness".

Table 1. Fertility Relationships in Range-Bred Bulls in Queensland

Site (n)	**A (10)**	**B (8)**	**C (12)**	**D (10)**	**E (9)**	**F (23)**
Domin.	-	ns	***	***	-	-
Scrot. Circ.	**	ns	ns	ns	ns	ns
% Motile	ns	ns	ns	-	ns	ns
% Normal	ns	**	ns	**	*	***
Sex-drive	ns	**	ns	-	ns	ns

Holroyd et al 1998

Domin = Dominance, Scrot. Circ. = scrotal circumference, ns = not significant,

- $P<0.05$, ** $P<0.01$, *** $P<0.001$

From these studies it may be concluded the BSE is an effective tool for reducing uncertainty associated with bull purchase and usage. A conservative estimate, based upon research (Wiltbank and Parrish 1986) is bulls passing a BSE (and/or semen quality tests) have a 6% or greater fertility advantage over unevaluated bulls. Larger differences are, of course, possible when satisfactory bulls are compared with those that fail the BSE.

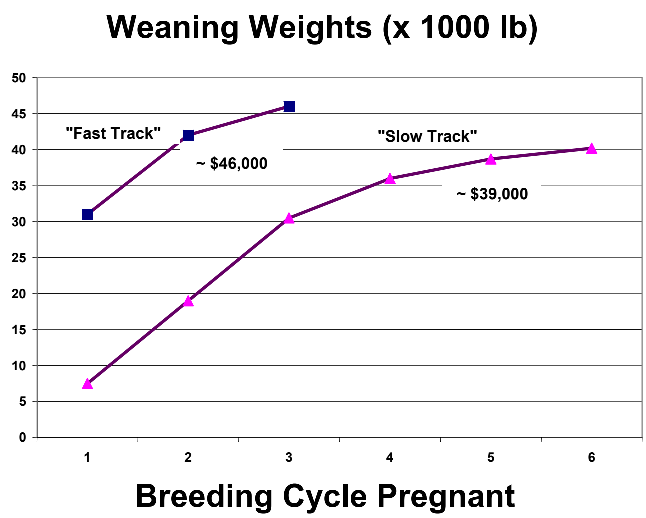

Figure 1. Cumulative Weaning Weights and Gross Returns ($1/lb) for Bulls Differing in Fertility by 6%.

In addition to increased calf crop, benefits accrue through increased weaning weights of older calves at weaning because females become pregnant earlier in the breeding season (Fig 1). Here, 2 bulls ("fast track" and "slow track") are compared, both of which eventually achieved the same percent pregnancies (94%) in their respective herds. However, the "fast track" bull achieves this in 3 cycles, while the "slow track" bull takes 6 cycles to do the same job. For a hypothetical U.S. herd of 100 females, this resulted in a difference of $7000 in calf sales (based on $1/lb). Missing one breeding cycle costs approximately 20 kg in individual calf weight at weaning time. A Texas study showed that cows placed with satisfactory BSE bulls weaned 7.4% more calves than those bred to untested bulls[6]. Based upon current U.S. prices, a 6% increase in calf crop at weaning would represent an approximate return of $20-$25 for each 1$ invested in the BSE.

Behavioral Aspects of Bull Fertility

Bull Sex-Drive. The ability of a bull to produce an adequate amount of good quality semen does not guarantee he has superior reproductive performance. This can be compromised by other considerations such as bull sexual behavior (or that behavior associated with the detection and service of estrus females). In turn, this includes libido, or sex drive, which is the willingness or eagerness of a bull to attempt mounting and service. Mating ability refers to the ability of the bull to complete service. Serving capacity is a measure of the number of services achieved by a bull under stipulated conditions and thus includes aspects of both libido and mating ability.

Libido is a measurable behavioral trait. Testing procedures developed for bulls benefit from knowledge that:

1. Bull libido has a significant genetic component
2. Bulls are polygynous and tend to distribute their services among receptive females.
3. The greatest single stimulus for bulls to mount and service is an immobile object that resembles the rear end of a female

4. Prestimulation of bulls increases their sexual response
5. Competition among bulls can increase their sexual response

Fertility Relationships. There is convincing evidence bull libido is one of the more important contributing factors to fertility in natural breeding herds. For example, in one study, better first-cycle pregnancy rates were obtained in heifers mated with higher-serving-capacity bulls than in those mated with bulls of low serving capacity (Blockey, 1978b). More recently, differences in pregnancy rates were demonstrated between high-, medium-, and low-serving-capacity Hereford bulls (Blockey, 1989). Other studies have shown advantages in herd fertility for bulls with higher sex drive (Chenoweth, 1997). In Texas, one study showed bull libido assessment provided greater prediction of bull fertility than did semen assessment alone (Smith et al, 1981). Several studies employing multi-sire mating and progeny identification have shown positive relationships between measures of bull sex-drive and their calf-getting (Coulter and Kozub, 1989; Holroyd et al 1998).

However, other studies have revealed poor or inconclusive relationships between bull libido–serving capacity assessment and herd fertility or pasture performance (Chenoweth, 1997), even though higher-libido bulls serviced more often and serviced more females than did lower-libido bulls in the breeding pasture (e.g. Boyd et al, 1989; Farin et al, 1989; Godfrey and Lunstra, 1989).

Such apparently contradictory findings may occur due to differing approaches and methodologies. In some trials, bulls were not placed under sufficient breeding stress to demonstrate differences, or bulls of potentially low fertility were excluded from cooperative breeding trials. Factors associated with BSE (scrotal circumference, sperm motility, and sperm morphology) can separately influence fertility and are apparently not linked with sex drive. Even though bulls may be superior in one trait, their fertility can be compromised by a deficiency in another. This was well illustrated in one study (Farin et al, 1989) in which 92 beef bulls were placed both into satisfactory and questionable BSE categories, as well as into high (score 9 to 10) and medium (score 7 to 8) libido categories before single-sire mating with groups of estrus synchronized heifers. Here, pregnancy rate was 9.1 percent higher for satisfactory BSE bulls compared with those in the questionable BSE category, but it did not differ between bulls of high and medium libido score even though high libido bulls serviced more females and served more times than did medium libido bulls. This apparently occurred because less serviced females in the high libido group became pregnant than in the medium group. Here, differences between bulls in sex drive were clearly masked by differences in their BSE components.

The ability of bulls to service females is related not only to their inherent sex drive but also to their mating ability. Problems in mating ability may be due to a number of physical and pathological causes, including skeletal and penile abnormalities (Chenoweth, 1983). Here, use of libido–serving capacity test procedures can be of value in detecting such problems. Other factors can influence the development and expression of bull sex-drive and competent mating behavior. These include not only genetic aspects (such as breed differences), but also age and rearing effects (including all-male raising, and previous heterosexual experience) and social (dominance) effects within the breeding pasture.

Table 2. Least-Square Means of Mating Performance within Breeding Soundness Examination and Libido Classifications				
	Exam classifications		**Libido**	
	Sat.	**Quest.**	**High**	**Medium**
No. bulls	80	12	69	23
No. mounts	146.3	120.7	112[c]	155[d]
No. services	47.8	42.4	52.8[e]	37.5[f]
Mounts:services	5.8	4.8	3.1[e]	7.5[f]
Serviced/estrus (%)	73.5	71.4	81.3[e]	63.5[f]
Pregnant/serviced (%)	56.1	50.8	51.8	56.1
Pregnant/estrus (%)	44.8	36.7	43.7	37.8
Total pregnancy rate (%)	45.6[g]	36.5[h]	41.5	40.6

Farin et al. (1989)
[c,d]Means differ ($P < .05$)
[e,f]Means differ ($P < .01$)
[g,h]Means differ ($P < .10$)

Conditioning & Preparation Prior to Breeding

Acclimation & Quarantine. This is an important period for several reasons.

Firstly, it enables the bull to adapt to his new environment (temperature, feed, water, "germs & bugs").

Secondly, it enables the owner to quarantine new bulls and observe for any signs of disease (as well as other problems).

Thirdly, it provides an opportunity to get the new bull into the same health program (vaccinations, anti-parasitics, trace elements etc) as the rest of the herd.

Re-location and associated adaptation problems are often not diagnosed until bulls have been resident on the property for some time. Then they are often represented by reduced pregnancy rates or delayed and strung-out calving. Although the causes of such problems may be multiple, and the effects both real and perceptual, recommendations to minimize the risks of this occurring include:

- Bring bulls from afar when conditions are optimal at the new site.
- Introduce bulls to their new environment gradually by holding and feeding them in yards initially, then releasing them into small paddocks under supervision, and
- Purchase yearling bulls so they have time to environmentally and socially adapt.

Breeding Management

Use of Young (1-2yo) Bulls

If genetic progress in a population is a function of both heritability of favorable trait(s) and generation interval, then young bulls should help maximize genetic progress in the herd (especially if mated with heifers). It is not uncommon for young bulls to be placed into service soon after purchase, with variable results. Rate of testicular development, puberty onset, and development of a stable spermiogram, are all largely dictated by genotype-environmental interactions (Fields et al 1979: Perry et al 1991). Despite this, scrotal size at puberty is remarkably consistent (26-27 cm) across different breeds and environments (Coulter 1994)

Young bulls are used widely. For example, NAHMS 1998 reports that, in breeding herds containing more than 50 females, over one half used bulls of less than 18 months of age. Surveys indicate young bulls are generally given lower mating loads than older bulls (Chenoweth 2000), and research tends to vindicate this approach. Aspects that have been neglected is loss of body weight, and attrition rates in young bulls. Here, Ellis (2003) reported yearling beef bulls lost considerable body weight over the breeding period, in conjunction with significant decrease in normal sperm and an overall lameness incidence of 64%. At conclusion of breeding, 35% less bulls were classified as satisfactory compared with at the beginning of breeding.

Studies on sexual development in early post-pubertal bulls show that there is a variable period during which they exhibit elevated levels of secondary sperm abnormalities (Coulter 1994). Over-conditioned bulls often require several months of "let-down" before they achieve "freezable" semen quality. In breeding trials with synchronized females in Colorado, yearling bulls achieved lower fertility than older bulls, despite having passed the BBSE, and exhibiting similar sexual activity (number of estrous females detected and serviced) as did the older bulls (Chenoweth 1994). Similarly, in Queensland, a comparison of the pregnancy patterns achieved by 1 and 2yo bulls indicated significant differences in favor of the 2 yo bulls in terms of pregnancy rate (5.2 pregnancies/wk vs 4.3. pregnancies /wk, respectively). At any given time, the yearling bulls were only 59% as successful as the older bulls in achieving pregnancies (Fordyce, unpublished data).

What are the constraints on young bull fertility? If we rule out sexual activity (apart from a variable learning curve for mating ability), then the major constraints are likely those associated with sperm production – both quantitative and qualitative – although this has yet to be ascertained.

Multi-Sire Breeding and Bull-to-Female Ratios

Traditional recommendations for bull-to-female ratios (BFR)s of 1:20-1:30 for herd bulls considerably underestimate the capabilities of competent bulls. For example, one study compared single- and multi-sire systems with Hereford bulls at BFRs of 1:25, 1:44 and 1:60 (Rupp et al 1977). *Here, the conclusion was the fertility, libido and mating ability of individual sires were more important than either BFR or single- vs multi-sire breeding systems.*

In Colorado, yearling Hereford bulls, pre-assessed for BSE and libido, were compared at BFRs of 1:20 and 2:40 with estrus-synchronized crossbred heifers (Farin et al 1982). Overall, bull mating performance and pregnancy rates did not differ between BFRs. Comparison of a variety of single-sire BFRs (1:7 to 1:51), also with estrus-synchronized females, found that BFR was not a limiting factor to fertility, even at the lowest BFRs (Pexton et al 1990). Two studies conducted in vastly different environments showed BSE-screened bulls increased herd pregnancy rates at reduced BFRs (1:20 to 1:33) (Prince et al 1987; McCosker et al 1989).

Thus it is apparent sound bulls which have passed a BSE can handle considerably more females during a generic breeding season than traditional recommendations would suggest. It is also evident most producers have yet to take full advantage of these findings. For example, U.S. surveys indicate cattle-breeding operations overall use yearling bulls at 1:17.5 and mature bulls at 1:25; figures, which have changed little in recent years (USDA, NAHMS 1998). Cattle breeders in the Rocky Mountain West used a mean BFR of 1:21, with 25% of herds employing a BFR of <1:18 (Sanderson et al 1996). Belated recognition of the capabilities of competent bulls has come with more recent US industry recommendations for bull ratios of 1:40 (mature) and 1:15-20 (yearling) (Ewbank 1996).

Influence of Breeding Paddock Size and Terrain

Female cattle tend to form a sexually active group when more than several are in heat/close to heat at the same time. This group is very mobile, but tends to seek out the bull or bull group and keep within eyeshot. In a smaller, easily traversed paddock, this is a relatively simple system. However, as distances get greater, especially when there are physical obstacles (eg creeks, hills etc), then several groups may form, each with their own bull(s). Under such conditions it is difficult to make inflexible recommendations BFRs.

Managing Bull Social Behavior

In multi-sire breeding herds, recommendations are the bull group is relatively homogenous (age, size and breed-type), relatively young (< 3.5- 4yo), and they have been allowed to establish their social ranking prior (at least 1-2 weeks) to commencement of the breeding season.

Bull Rotation

Although data is lacking, it is often recommended to rotate bulls during the breeding season for optimal performance (Ewbank 1998).

One approach is to use more mature bulls at commencement of the breeding season, and younger bulls in the latter part of the season. Another approach is to rotate mature bulls with younger bulls at 2- week intervals. Either approach is considered to limit the harmful effects of social dominance, while maximizing biostimulation.

Rest & Recreation

Bulls should not be ignored during the period they are not with females. During this time, they should be managed to ensure optimal performance in their next breeding season, so their reproductive life span is prolonged. Thus, emphasis should be placed on maintaining bull condition, attending to relevant herd health practices (vaccination, parasites), protecting bulls from injury and adverse environmental effects (within reason) and promoting growth and development of young bulls.

Conduct of a post-breeding appraisal is good management, especially considering the attrition rate encountered in young bulls by Ellis (2003). This examination enables “dud” bulls to be culled, and fixable problems to be attended to during the “off” season.

Attention to nutrition over this period is also important. Mature and young bulls should be fed different diets according to their different needs. This may involve separation based on age. It is also useful to keep bulls in homogenous groups in paddocks which are large enough to allow for adequate exercise, and which provide protection (e.g. shade trees) from extreme weather conditions.

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