Bull Behavior, Sex-Drive and Management

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Introduction

Reproductive performance has greater impact on beef economic returns than does either growth rate or product quality (Trenkle and Wilham, 1977). In most cow-calf operations, females still conceive via the natural breeding bull (Godfrey and Lunstra, 1989). Thus the reproductive capabilities of bulls are of paramount importance. These capabilities are largely influenced by one or more of the following factors: a) semen quantity and quality, b) libido and mating ability and c) social interactions (dominance effects) in the breeding pasture. In addition, bull performance is limited by the fertility threshold of the female herd.

The breeding soundness examination of bulls (BSE), as recommended (Society for Theriogenology, 1976), is useful in identifying bulls which have physical problems, or poor semen quality. However, other problems do not become apparent until bulls are exposed to some form of mating ability assessment (Blockey, 1975). In many cases, bulls receive no form of assessment prior to sale or use (Godfrey and Lunstra, 1989).

Some Definitions

Libido is defined as the "willingness and eagerness" of a bull to attempt to mount and service, while mating ability refers to the ability and competence of the bull in fulfilling this aspiration (Chenoweth, 1981). Serving capacity is a measure of the number of services achieved by a bull under stipulated conditions (Blockey, 1976) and thus includes aspects of both libido and mating ability. Some problems have occurred with terminology in the past (Wodzicka-Tomaszewska et al.,1981; Price, 1985; Morris, 1987) mostly because of confusion between the trait and the method used to assess it. Libido, or sex-drive, is a behavioral trait with a large instinctive component and as such it poses problems in its assessment and interpretation. However, it is a trait which is measurable and testing procedures designed for the bull generally rely on the exploitation of several or more of the following findings:

1. Libido in bulls has a large genetic component (Bane, 1954; Chenoweth et al., 1977; Blockey, 1978a; Ologun et al., 1981).
2. Bulls are polygamous and tend to distribute their services among receptive females (Blockey, 1976).
3. The greatest single stimulus for a bull to attempt mount and service is the immobile rump of a female, or something similar (Chenoweth et al., 1979; Blockey, 1981; Wallach and Price, 1988).
4. Prestimulation of bulls increases their sexual response (Blockey, 1981; Mader and Price, 1984).
5. Competition among bulls can increase their sexual response (Mattner et al., 1974; Mader and Price, 1984; Godfrey and Lunstra, 1989).

Historical Aspects

Early interest in bull libido and mating ability developed from problems encountered with semen collection from some bulls in A.I. centers. Work in Sweden, Africa, Scotland and the U.S., mostly between 1945 and 1965, helped to define testing procedures, illustrated the strong genetic basis of both sex-drive and mating ability, and probed the limits of bull sexual performance (see reviews by Chenoweth, 1983a and Price, 1985.). Osborne et al. (1971) first described a scheme for assessment of untrained beef bulls (libido score), using estrogenized unrestrained females as stimuli and a short test (5 min). This procedure was later modified with an expanded 0 to 10 scoring system (Chenoweth, 1976), which described degrees of sexual interest including service, and a 10 min test.

Blockey (1981) devised a serving capacity test which group-tested bulls with restrained, non-estrus females for 40 to 60 min. A score was given based only on services performed. A composite procedure employing elements of both systems has been described (Chenoweth, 1980), and procedures exploiting features of the serving capacity test have been described (Lunstra, 1980; Boyd et al., 1989; Godfrey and Lunstra, 1989).

Repeatability and Predictability

An ideal procedure for assessment of bull libido would be simple, quick, highly repeatable and very predictive of actual reproductive performance. Unfortunately, no test is currently available which fulfills all of these criteria although relative differences between bulls can be reliably estimated (Price, 1985). Chenoweth et al. (1979) obtained moderate phenotypic correlations (r = .67 and .60 respectively) between libido and serving capacity scores in yearling bulls tested on different days; reaction times to service were not significantly correlated with the two scores. Fifty-seven percent of the young bulls did not achieve a service in both serving capacity tests and thus were not scored. However, when 26 yearling Bos taurus bulls were assessed eight times (two tests per day on four occasions within 2 mo), four tests were required before test results did not differ (Berndtson, personal communication). There was strong evidence in these trials for expression of a learning curve in young bulls. This phenomenon was also observed by others (Boyd et al., 1989; Godfrey and Lunstra, 1989) when yearling bulls with low serving capacity scores improved with mating experience. These latter workers found it advantageous to conduct three assessments prior to categorizing bulls. If the ratio of mounts to services can provide an indication of mating inexperience (Chenoweth, 1978a), then such inexperience was most evident in bulls at 12 mo of age (Katz and Price, 1984). Boyd et al. (1989) suggested that young, virgin bulls which show poor serving capacity should be offered sexual experience and retested to determine their true worth.

Best success has generally been obtained when using assessments of libido or serving capacity to place bulls into categories or groups. Thus Lunstra (1984) found that eight Hereford bulls maintained their relative ranking for both libido scores and fertility when assessed at both 16 and 40 mo of age. Blockey (1981) obtained high correlations for mating activity rankings between simulated pasture tests and subsequent pen tests (r = .82 to .91) in 12 Bos taurus bulls.

In conclusion, it appears that libido and serving capacity tests are useful in placing bulls into groups which will then reflect their test results in pasture mating activity. Bulls obtaining poor to moderate results may require more than two tests for adequate categorization. Young bulls can improve their scores (and ranking) with mating experience.

Relationships with Reproductive Performance

Although cattle fertility is influenced by many factors, there is evidence that bull libido is of considerable importance. Blockey (1978b), for example, obtained better first-cycle pregnancy rates in heifers mated with higher serving capacity bulls when compared with bulls of low serving capacity. A more recently published study (Blockey, 1989) showed differences in pregnancy rates between high, medium and low serving capacity Hereford bulls. Other studies which have shown advantages in expressed fertility have included those of Makarechian and Farid (1985), and Morris (1987). Libido and semen quality both influenced pregnancy rates of Brangus bulls in Florida, with libido having most effect (A.C. Warnick, personal communication). Other studies have indicated either that bull libido assessment provided greater prediction of bull fertility than did semen assessment alone (Smith et al., 1981), or that BSE assessment alone was lacking in predicting bull fertility (Neville et al., 1988). Using multi-sire mating and progeny identification by blood typing, Coulter and Kozub (1989) showed that the number of services performed in prior libido/serving capacity tests was positively correlated to fertility up to a certain point only (approximately four services), above which fertility actually declined with subsequent services.

Other studies have shown poor or inconclusive relationships between bull libido/serving capacity assessment and herd fertility (Chenoweth, 1978b; Christensen et al., 1982; Farid et al., 1983; Makarechian et al., 1987; Boyd et al., 1989; Farin et al., 1989). In some studies, although higher libido bulls serviced more often and serviced more females than did lower libido bulls, more pregnancies did not result (Boyd et al., 1989; Godfrey and Lundstra, 1989; Farin et al., 1989).

Although some of these findings may appear contradictory, they are not necessarily so. In a number of trials, bulls were not placed under sufficient breeding stress to illustrate real differences, bulls at the bottom end of the spectrum were not included, and investigators erred in concentrating on single trait effects on herd fertility. As stated earlier, cattle fertility is influenced by a number of factors of which bull libido is but one. Breeding soundness and examination components (scrotal circumference, sperm motility and morphology) can separately influence fertility (Mateos et al., 1978), but do not appear to be genetically linked with behavioral traits such as libido (Chenoweth et al., 1977; Morris, 1987; Boyd et al., 1989). Thus bulls may be superior in one or more traits but their fertility can be compromised by deficiencies in others. This was illustrated in a study by Farin et al. (1989) in which 92 beef bulls were placed into satisfactory and questionable BSE categories, and into high (score 9 to 10) and medium (score 7 to 8) libido categories prior to single-sire mating with groups of estrus synchronized heifers (table 1).

Several points are apparent. Although bulls at the lowest end of the BSE scale were not used, there was a difference in pregnancy rate of 9.1% between bulls in the satisfactory and questionable categories. There appeared to be little relationship between the BSE and libido categories. Bulls of high libido achieved a similar overall pregnancy rate to that of bulls of medium libido, despite their achievement of more overall services and more females serviced. This paradox was apparently due to a lower percentage of serviced females becoming pregnant in the high libido group. Differences in libido between bulls can be masked by differences in other facets of reproductive capability such as breeding soundness components.

In conclusion, it would appear that libido and serving capacity tests are useful in identifying bulls which have superior breeding activity (i.e. serve more often and serve more females than do other bulls). However, the BSE classification aids in identifying differences in ability to impregnate at those services. Optimum prediction of bull fertility would require separate assessment in both categories.

Factors Influencing Bull Libido

1. **Age and rearing effects.** As mentioned previously, age and(or) experience of bulls can influence their relative efficiency of

mating, and consequently their libido scores and rankings. Thus, mating ability has a learning component (Chenoweth, 1981).

In trials with young tropical beef bulls, libido score apparently increased with bull age between 16 and 31 mo (Chenoweth, 1978b); a finding which differed from results with bulls in Sweden (Hultnas, 1959), and with Hereford and Angus bulls in Colorado (Chenoweth et al., 1984). Coulter and Kozub (1989) found that age affected sexual behavior traits in crossbred bulls, with yearling bulls showing lower libido and a higher proportion of mounts than older bulls. More work is needed to differentiate the effects of age and inexperience from the influences of different environments and rearing methods. In this respect, prolonged nursing was considered to retard the expression of normal sexual behavior in Angus bulls (Couttie and Hunter, 1956) and Hentges (1967) reported lowered libido in bulls fed high concentrate levels. Ologun et al. (1981) identified negative relationships in yearling beef bulls between sex-drive and production traits, while in another study, underfeeding had no adverse effects on bull sexual behavior (Wierzbowski, 1978). McFarlane (1974) showed that Zebu bulls raised on open range showed tardy sexual responses compared with those reared more intensively. No permanent sexual inhibitions attributable to rearing methods were reported in bulls (Lane et al., 1983) as distinct from rams (Zenchak et al., 1981), although it is quite possible that temporary inhibitions may compromise restricted breeding seasons (Chenoweth, 1981). Fertility in yearling bulls may, however, be reduced for reasons other than those associated with libido or mating behavior. For example, in trials employing bulls with estrus synchronized heifers, yearling bulls obtained lower fertility than older bulls despite equivalent mating activity (table 2).

In this study, yearling bulls did not differ from older bulls in either the number of services or heifers serviced. There were differences in the number of mounts performed. More importantly, differences were encountered in the percentages of females pregnant, either of those in estrus and of those serviced. Yearling bulls were as sexually active as the older bulls, but less fertile.

2.**Bull to female ratio.** The standard recommendation of using approximately one bull per 20 to 30 females has long been promoted. It is apparent, however, that this does not represent optimal bull usage and that it allows sub-standard bulls to go undetected.

Bulls not selected for high libido have shown estrus detection rates from 90 to 98% when used at a bull to female ratio (BFR) of 1:24 to 1:30 (Donaldson, 1968; Mattner et al., 1974). Beerwinkle (1974), using ratios of 1:60 and 1:100, obtained rates of 64% and 51%, respectively.

In contrast, Rupp et al. (1977) obtained good reproductive efficiency with most bulls in single sire mating at BFRs of both 1:44 and 1:60 and concluded that a BFR of 1:25 represented inefficient bull usage. Comparison of single and multi-sire combinations revealed no effect of number of bulls in the pasture on estrus detection. The overall conclusion was that the reproductive capabilities of individual bulls were more important to reproductive success than either BFR or single vs multi-sire breeding combinations. Farin et al. (1982), mating young bulls with estrus synchronized heifers, compared BFRs of 1:20 and 2:40 and concluded that single sire mating was more efficient. Heifers in single-sire groups were serviced more times than those in multi-sire groups, and approximately 50% of heifers in the latter groups were serviced by both bulls.

Overall, there seems little doubt that bulls are greatly under utilized in many breeding programs. Although not practicable in many cases, single-sire mating is inherently more efficient than multi-sire mating. The individual capabilities of bulls have greater impact on herd fertility than do BFRs and these capabilities can generally be assessed prior to the breeding season to minimize risk.

3.**Social effects.** Social ranking of bulls within groups can influence their sexual activity (Chenoweth, 1981). Several studies employing blood-typing methods to determine paternity, have shown that dominant bulls can sire the majority of calves in multi-sire groups (Farid et al., 1983). Dominance is expressed more strongly and linearly in older bulls (>3.5 to 4 yr) and appears to be more related to seniority than to age or weight (Blockey, 1979). The effect of social interactions among bulls on herd fertility may be greater at lower BFRs than where there is higher breeding stress (Blockey, 1979).

Dominance rank was negatively correlated with sex-drive in one study with yearling bulls (Ologun et al., 1981). If dominance and sex-drive are different traits, then the dominant bull (or bulls) could impair herd fertility through failure to service females while preventing less dominant bulls from serving. Evidence has been presented for such effects occurring in extensive beef operations (McCosker et al., 1989) where it was also shown that social dominance ratio of bulls had some relationship with herd fertility. In rams, the reproductive performance of subordinates was shown to be greatly reduced (Fowler and Jenkins, 1976). Such effects are probably most evident when older and younger males are combined in the breeding pasture (Blockey, 1979), although mixing different bull genotypes has apparently caused similar effects.

In conclusion, social effects should be considered in both the breeding pasture and during libido/serving capacity tests. With multi-sire mating programs, more efficient breeding and sire utilization would occur if the bull groups were young (preferably < 3 yr), of similar age, size, genotype and social background.

4.**Genotype differences.** Anecdotal evidence for breed differences in bull sex-drive has long been reported. For example, differences between beef and dairy breeds in semen collection ease are noted (Amann and Almquist, 1976). Zebu bulls have a reputation for "sexual sluggishness" and a tendency to mount females in full estrus only (Anderson, 1948; Hafez, 1960). When comparing libido scores of six breed groups in Queensland, those bulls with a Brahman component in their breeding had consistently lower scores than either British or Africander derived breed types (Chenoweth and Osborne, 1975). With subsequent trials, Bos indicus genotypes generally did not perform successfully in serving capacity type tests employing restrained females. More success was obtained with the use of unrestrained estrus-induced females and single bull tests. It was obvious that the testing procedure was more unsettling to a number of these bulls than with the Bos taurus bulls. Even in the breeding pasture, difficulties were encountered in observing mating behavior because of apparent wariness by the bull(s) towards the observer. Despite this, the best performing Bos indicus bulls were equal to the best of the other genotypes. Interestingly, when different trials employing either Bos taurus or Bos indicus bulls mated with synchronized females were compared (table 3), the Bos indicus bulls achieved similar fertility although they displayed less sexual activity.

Pitfalls in Libido/Serving Capacity Testing

In general, successful testing of bulls for libido and mating ability requires careful planning and lots of patience. Some of the pitfalls which may be encountered (Chenoweth, 1983b) are described as follows:

1. **Testing of bulls that are excessively apprehensive or agitated.** Apart from taking precautions to handle cattle quietly and to avoid distractions, there is

no easy solution to this problem, which can lead to depressed scores.

2. **Testing of bulls immediately following their subjection to other procedures such as electroejaculation, vaccination and parasite control measures.**
3. **Testing under adverse weather conditions, such as in extreme heat, cold, or inclement weather.**
4. **Testing of bulls in groups in which one or more bulls are markedly dominant, such as with mixed-age groups of bulls.** The exposure of only two bulls to test at a time, and subsequent retesting with a different bull, helps to minimize this problem. It should be noted, however, that a dominant bull can exert an inhibitory effect from a distance (eg. from an adjacent pen).
5. **Use of inadequate stimuli.** Restrained females should be incapable of excessive movement or some bulls may be deterred. The service crates used should not impede mounting and service. If unrestrained females are used, they should be in full estrus.
6. **Spreading of venereal diseases.** Every precaution should be taken to ensure that diseases such as vibriosis and trichomoniasis are not transmitted by such procedures.
7. **Injury or undue stress to restrained females.** Humane considerations mandate that females be closely monitored for signs of stress and be replaced if these become evident. Mild sedation of females and prior lubrication of their genital regions are also recommended.

Alternative Assessment Procedures

The indirect determination of bull libido as reflected by blood concentrations of hormones has some attraction as it could reduce or eliminate the time, labor and aesthetic concerns which occur with libido/serving capacity testing. This would also allow assessment of bulls which did not respond well to yard or pen testing. Earlier attempts at linking luteinizing hormone (LH) or testosterone (T) levels with bull sex-drive were, however, disappointing (Foote et al., 1976; Chenoweth et al., 1979). Difficulties were posed by the episodic nature of hormone release and the inhibiting effects of handling or restraint of the animal (Rhodes et al., 1979). By inducing LH or T release with parenteral administration of gonadotropin releasing hormone (GnRH), a number of these difficulties have been avoided. Post et al. (1987) reported a significant relationship between induced T levels and bull fertility, while Perry et al. (1988) obtained positive relationships with induced LH levels. Work is proceeding with such indirect tests to define dosages, sampling times and the effects of bull age, genotype, season and nutrition. Although criticism has been levelled at such procedures for not allowing concurrent assessment of mating ability, the additional use of the BSE and judicious pasture observation should minimize these concerns.

A Fertility Index for Bulls?

It is apparent that a number of factors influence bull fertility, including BSE values and behavioral factors such as dominance and libido, and that these do not always work in harmony. Attempts have been made to combine a number of these factors to best predict bull performance. Perry et al. (1989) assessed a number of traits in young tropical beef bulls at varying intervals from single-sire matings (10 wk). The traits assessed included BSE values, sex-drive (libido and serving capacity), production traits (ADG and body weight), tick resistance and LH and T responses to GnRH. A step-wise regression procedure was used to select the most suitable combinations of traits highly correlated with pregnancy rate. Fertility indices were calculated from this analysis (table 4).

The fertility indices derived were, in general, highly predictive of pregnancy rate, even at 11 mo prior to mating. The lowest correlation was the one obtained at the examination just prior to breeding ($r = .45$; $p < .05$) when the only trait included in the index was libido score. Genotype differences had little influence on these indices. Overall, the most important measurements were GnRH induced LH levels, testicular volume, libido and body weight. Interestingly, these factors are derived from each of the main categories separately known to influence bull reproductive performance, i.e. sex-drive, endocrine status and sperm production. These results also showed that relationships change with bull age and interval to mating and perhaps illustrate the variability of semen traits during the post-puberal year and a growing importance of sex-drive during this period.

Coulter and Kozub (1989) also used a regression model to predict bull fertility in multi-sire breeding where paternity was determined by blood typing. The most important traits were found to be scrotal circumference, backfat, sperm morphology (particularly primary abnormalities) and sex-drive. In yearling bulls, the model accounted for 37% of the variance in bull fertility and in 2 yr-old bulls it accounted for 22%.

In conclusion, the best prediction of bull fertility is obtained when bulls are assessed for a number of traits, including sex-drive. The development of fertility indices, which combine a number of important traits, should improve predictive ability. They already provide considerable advantage over single trait measurements.

Summary

Bull libido is a measurable trait, largely under genetic control, and is an important component of bull reproductive performance. It can be measured in a number of ways but a formalized procedure is necessary to quantify this trait. Libido does not necessarily work in concert with other traits known to separately influence bull fertility (e.g. BSE traits and social dominance). Until a single procedure is found that can adequately assess all of these factors, optimal bull appraisal requires separate evaluation of each factor. The development of bull fertility indices promises to combine the best of these measures for optimal bull fertility prediction.

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Table 1. 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:serivces	5.8	4.8	3.1[e]	7.5[f]
Serivced/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

c,d Means differ (P < .05)
e,f Means differ (P < .01)
g,h Means differ (P < .10)

Farin et al. (1989)

Table 2. Mating Performance as Affected by Age of Hereford and Angus Bulls			
	Age (yr)		
	One	Two	Three+
No. bulls	29	36	27
No. mounts	207.1	120.0[d]	85.8[d]
No. services	54.5	37.6	40.5
Mounts:services	6.6:1	5.4:1	4.5:1
Serviced/estrus	69.4	73.8	72.0
Pregnant/serviced	39.6[c]	59.4[d]	62.2[d]
Pregnant/estrus	30.2	40.3[d]	50.7[e]
Total pregnancy rate	30.9[c]	41.5[d]	49.9[e]

c,d,e, Means differ (P < .05).

Pexton, Farin, Rupp and Chenoweth (in press)

Table 3. Comparison of Bull and Synchronization Trials with Bos taurus and Bos indicus Cattle			
	Bos taurus[a]		**Bos indicus**[b]
	SMB	**PGF**	**SMB**
No. groups	39	53	31
BFR[c]	1:7 to 51		1:15 to 20
Females in estrus (%)	90.8	78.3	77.2
Estrus/served (%)	73.3	70.4	72.0
Total females served (%)	66.1	55.1	55.7
Avg. services per bull	45.1		23.6
Pregnant/estrus (%)	42.4	41.0	40.6
Pregnant/served (%)	56.4	56.1	57.3
Pregnant/total (%)	41.3	42.7	32.6

[a]Pexton et al. (1989)
[b]Williams (1988)
[c]BFR=bull to female ratio

Table 4. Fertility Index Correlations with Pregnancy Rate in Young Beef Bulls

Interval to mating (mo)	Within or Among mating	Trait in index	Correlation with pregnancy rate
-11	Within	LH	0.75^{**}
	Among	LH, D, Tvol	0.71^{**}
-8	Within	Lib, Bwt, Tvol	0.89^{**}
	Among	Lib, Bwt, Tvol	0.76^{**}
-6	Within	Bwt, Tvol	0.86^{**}
	Among	Bwt, Tvol	0.73^{**}
-2	Within	LH	0.80^{**}
	Among	LH, Age	0.66^{**}
-0.5	Among	Lib	0.45^{*}

Legend: LH = induced LH level (* = P < .05)
D = dominance value (** = P < .01)
Lib = libido score
Bwt = bodyweight
Tvol = testicular volume
Age = bull age (d)

Perry et al. (1989)