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The Importance of Reproductive Behavior Tests in Bull Breeding Soundness Evaluation

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In extensive beef cattle farms, fertility is one of the factors that determines the number of calves born each year and is therefore essential for maintaining a farm's competitiveness and sustainability. In farms where natural breeding is the usual reproductive management strategy, bull reproductive soundness should be assessed to exclude animals that may compromise productivity. The standard method of evaluation, known as bull breeding soundness evaluation, comprises health, physical, seminal, and behavior assessment. However, veterinarians in many countries often omit the behavior assessment from bull breeding soundness evaluation because of its complexity and resource requirements. Instead, farmers closely observe bulls during the first weeks of the mating period to detect problems with libido or mating ability. We believe that detecting "problematic bulls" before mating period through reproductive behavior tests should be considered. To develop tests that may prove more affordable and easier to perform, we examined fundamentals of serving capacity, libido, and mating ability as main reproductive behavior tests. This approach may turn the reproductive behavior tests more affordable so they can be included in the bull breeding soundness evaluation performed at medium-sized cattle farms.

Keywords: libido, serving capacity, mating ability, sex behavior, breeding soundness

Introduction

Economic losses caused by reproductive inefficiency because of reduced numbers of calves is one of the main factors limiting the sustainability of extensive beef cattle farms (Bellows et al., 2002). Knowing the reproductive soundness of bulls before the start of their mating period can help reduce such inefficiency. The standard method to evaluate bull reproductive soundness—bull breeding soundness evaluation—was developed in the United States by the Society for Theriogenology (SFT; Hopkins & Spitzer, 1997). The Western Canadian Association of Bovine Practitioners (WCABP; Barth, 2000) and the Australian Cattle Veterinarians group (ACV; Entwistle & Fordyce, 2003) adapted the bull breeding soundness evaluation with several modifications, involving different cutoff values of scrotal circumference, sperm motility, and sperm normality. South Africa (Irons et al., 2007), the United Kingdom, and the Republic of Ireland in collaboration with the British Cattle Veterinary Association (BCVA;

Penny, 2018) agreed on their own bull breeding soundness evaluation system, considering (as had the aforementioned countries) all stakeholders involved in the development and application of this methodology.

After farms apply the bull breeding soundness evaluation, 20% to 30% of bulls are classified as unsatisfactory (e.g., Carson & Wenzel, 1997; Eppink, 2005; Higdon et al., 2000; Sylla et al., 2007), most of them classified as subfertile (Kennedy et al., 2002). In extensive beef cattle farms, bull breeding soundness evaluation is typically not performed; therefore, subfertile bulls may go unnoticed and become one of the leading causes of reproductive inefficiency (Burns et al., 2010). Notably, the negative impact of keeping a subfertile bull in a farm increases exponentially with reproductive demand (number of cows in estrus per day and per bull), especially when a single sire is used (Petherick, 2005).

The bull breeding soundness evaluation considers that bulls must pass health, physical, seminal, and behavior evaluations to be classified as "satisfactory." However, in most countries where the bull breeding soundness evaluation is used, farmers and practitioners usually ignore the behavior tests, which are complex and require certain facilities. Instead, farmers monitor bulls during the first weeks of the mating period to detect possible abnormalities in their libido or mating ability (e.g., Barth, 2013; Koziol & Armstrong, 2018; Penny, 2018; Schrag & Larson, 2016). However, the identification of "problematic bulls" through behavior tests performed within the bull breeding soundness evaluation methodology is considered more effective at providing relevant information for efficiently planning the reproductive management of bulls and cows on farms (Price & Wallach, 1991).

Australia introduced the bull reproductive behavior assessment protocols (Blockey, 1976a, 1976b) and integrated them into the bull breeding soundness evaluation (Beggs, 2013; Fordyce et al., 2006). Nowadays, the Australian guideline is considered the international reference for behavior tests. In Spain, this approach is also considered in new guidelines developed to promote national consensus on the bull breeding soundness evaluation procedure (García-Paloma et al., 2021). The guidelines can be found at https://produccionanimal.com/online/vart/. Most of the research that is reviewed is based on production systems typical of the United States, Canada, Australia, or Argentina, where the herds are large (> 500 cows) and certain testing are easier to implement.

Therefore, we aim to review the fundamental principles on which the three main tests of bull reproductive behavior are based (serving capacity, libido, and mating ability). From our analyses, we propose behavior tests that may be easier to implement when the bull breeding soundness evaluation methodology is applied in farms of varied sizes, not just large farms.

Fundamentals

Behavior tests try to predict, through quantifiable parameters, a bull's reproductive behavior on a farm when it is alone or in competition with others. Not all parameters used in behavior tests have been standardized in the literature, so we first provide some relevant definitions.

- *Libido:* Desire or repeated insistence of the bull to service cows in estrus. Libido encompasses the three main parameters to describe bull reproductive behavior: sexual interest, mounting, and mating or service.
- *Sexual interest:* Initial signs of courtship: raising the snout or *flehmen response* in search of olfactory stimuli, resting the head on the cow, and disoriented mounts.
- *Mounting:* Oriented mounting without ejaculation; the bull positions itself and hugs the back of the cow, with or without an erection.
- *Mating or service:* Oriented mounting with ejaculation: penetration of the penis, "kidney blow" as a defining sign of ejaculation, and dismounting with a flaccid and visible penis.
- *Reaction time:* Time elapsed from when the bull begins a behavior test until it performs the first service.
- *Libido test:* Test that quantifies three parameters of behavior: sexual interest, mounting, and mating or service.
- *Serving capacity test:* Test that quantifies the number of services.
- *Mating ability test:* Test that demonstrates the ability of the bull to complete a service.

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- *Single or group:* Participation of one or more bulls in the behavior tests and to the mating system used on a farm.
- *Reproductive requirement:* The number of cows in estrus that the farmer makes available to a bull at a defined moment, generally at the beginning of the mating period.
- *Ratio of the numbers of bulls to cows (B/C):* Parameter used to describe behavior testing protocols and mating systems.

Factors to Consider in Behavior Tests

Reproductive behavior tests can be difficult to interpret if the factors that affect the behavior are unknown (Table 1). Next, we describe factors related to the bull itself or to the protocols, reaction time, and welfare of the cows in the tests.

Age/Sexual Experience

Bull sexual experience, more than age, influences reproductive behavior, especially when bulls are evaluated as a group (Blockey, 1979). For this reason, instead of age, we use the expressions *virgin bull* and *experienced bull*. In behavior tests, virgin bulls tend to perform worse than experienced bulls because they engage in more disoriented and oriented mounts, their reaction time is longer, and they perform fewer services than a mature bull (Coulter & Kozub, 1989; Godfrey & Lunstra, 1989). One study (Bertram et al., 2002) confirmed the effect of sexual experience in improving the serving capacity of young bulls: Performance improved after the bulls had gone through a "learning phase" with a group of heifers in estrus.

Breed

Among behavior traits, libido has a marked genetic component (Ologun et al., 1981). In fact, the greater libido of Holstein bulls over that of other beef breeds, whether in herds or artificial insemination centers, is widely recognized (Chenoweth, 1981). Among the beef breeds, *Bos indicus* breeds are more inhibited in showing behavior signs than *Bos taurus* bulls (Chenoweth et al., 1996). For this reason, the behavior test protocols and the criteria for their interpretation must be different depending on the breed. In the present study, descriptions of serving capacity and libido tests, as well as the corresponding thresholds for their interpretation, refer to experienced bulls of all *Bos taurus* beef breeds.

Immobilized Cows

A key discovery for the development of modern behavior testing protocols was that it does not matter whether an immobilized cow is in estrus: The immobilized cow is sufficient to elicit the chain of mating reflexes in bulls, whether on farms or in artificial insemination centers (e.g., Chenoweth et al., 1979; Wallach & Price, 1988). Cow immobilization allows the evaluating technician to approach the bull, facilitating the observation of possible musculoskeletal anomalies and the external genital tract. It also prevents the assessment of bull reproductive behavior from being biased by variability in cow receptivity to repeated mating.

Table 1. Main Factors that Affect Behavior Tests.

Factor	Result on Test
Age/Sexual experience	Virgin bulls tend to increase testing time
Breed	Testing time is markedly increased in Bus indicus
Immobilized cow	Estrus is not compulsory. The immobilization of the cow is sufficient to elicit the chain of mating reflexes in bulls
Animal welfare	Bull/Cow rate 1/1 for group bull evaluation Enough number of cows per bull, to limit to a maximum of 10 mounts per cow It could be performed in 10–20 minutes Appropriate cow and bull handling
Positive stimulating factors	Visual stimulus by observing other bulls under evaluation Competition stimulus in the mating group Olfactory stimulus with sexual pheromones
Inhibition factors	Inappropriate environment Marked hierarchy
Facilities	Pens and breeding crates according to the behavior test Nonslip surface Appropriate in safety

Factors Influencing Animal Welfare

Type and care of cows participating in the tests. Cows with good body condition (3 or higher on a scale of 1 to 5; Edmonson et al., 1989), without any limb conformational defects, of adequate size, and with a weight greater than 75% of the bull should be chosen. Before the start of the test, 30–50 mL of an obstetric lubricant should be applied to the vagina and perivulvar area of the cow; depending on the temperament, the cow may also need to be lightly sedated with 0.03–0.05 mg xylazine/Kg intramuscularly (Chenoweth et al., 1979). After the test, the cows should be examined by a veterinarian to detect and treat possible sequelae produced by repeated mating. Depending on the number of bulls involved, additional cows should be available as replacements for those showing signs of fatigue or stress or those that exceed 10 matings (Barth, 2013).

Test duration. The duration of the test determines the number of services, cow welfare, and the probability of confrontations between bulls when the test is performed in a group. In 60-min serving capacity tests, up to 19 mounts by the same bull have been counted (Blockey, 1981a, 1981b). Current protocols usually last 10–20 min and involve two services per bull (e.g., Acuña, 2019; Entwistle & Fordyce, 2003).

Selection and management of bulls. Management guidelines have been established to reduce the probability of fights between bulls during group testing. Guidelines call for using bulls that have been together in the same pen for months prior to the test, such that their hierarchy has been established; using bulls similar in sexual experience, breed, and weight; and evaluating no more bulls than there are immobilized cows (e.g., Blockey, 1979, 1981b).

Stimulation Factors

Reducing the duration of behavior tests has been a major objective, not only to reduce the resources and costs involved but also to maintain good animal welfare. On the other hand, the tests should be long enough to allow observation of at least one service. Thus, stimulation factors have been used to shorten bull reaction time (e.g., Blockey, 1976b; Chenoweth, 1981; García-Paloma, 1984), several of which are described next.

Visual stimulus. The bull receives the visual stimulus when observing the sexually active group (SAG) in herds during the mating period. The cows in their proestrus and estrus phases that constitute the SAG clearly differ in behavior from the rest of the cows in the herd: They move continuously as a group with little dedication to grazing and carry out repeated mounts among themselves. The SAG is dynamic: The cows leave it at the end of the estrus, and other animals join it at the beginning of proestrus. Therefore, a bull's ability to detect the SAG and remain in it greatly facilitates its work as a mating bull.

In behavior tests, the visual stimulus has been incorporated by placing the bulls awaiting the test in a barnyard adjacent to the one where the test is performed so they can observe the bulls under evaluation at that moment. A duration of 10 min appears to be sufficient to stimulate bulls waiting to take the test (e.g., Blockey, 1981c; Mader & Price, 1984; Wallach & Price, 1988).

Competition stimulus. In farms where the group mating system is used, the dominant bull is usually part of the SAG, whereas subordinate bulls remain on the periphery, waiting for their opportunity to mate. Cows in estrus in the SAG will be mounted by the dominant bull and usually show resistance to being mounted again. Hence, the dominant bull normally has preference for mating new cows in estrus, whereas the repeated mounts will be carried out mainly by subordinate bulls (Blockey, 1976b).

In a mating group with bulls showing similar sexual experience, similar hierarchy, and similar weight, the probability that subordinate bulls carry out mounting increases, improving the pregnancy rate of the herd (Blockey, 1979; Chenoweth, 1981). This increase in the pregnancy rate may reflect that repeated mating with subordinate bulls can compensate for the dominant bull's limiting sperm load or lower fertility (e.g., Farin et al., 1989; Lunstra & Laster, 1982). Therefore, it is important to consider the intensity of the hierarchical relationship among the bulls to create an appropriate mating group. Otherwise, a dominant bull can prevent additional mountings from subordinate bulls.

Olfactory stimulus. The bull relies on olfactory stimuli to locate the cows that are receptive, and it becomes important when a SAG has not formed in the herd. Sexual pheromones in urine and vaginal secretions of cows in estrus arrive in the vomeronasal organ of the bull to provide olfactory stimulation (Jacobs et al., 1980). To try to reproduce the effect of pheromones, evaluators can use the urine of a cow in estrus, previously aliquoted and frozen, as an olfactory stimulus to be sprayed on the tail and perivulvar area of the immobilized cow. We have not found any published reports using this so far.

Inhibitory Factors

Inhibitory factors are considered to be those that can delay the reaction time of bulls during the behavioral tests.

Test environment. Behavior tests must be designed to prevent the bull from being distracted. Minimal personnel should be involved and should be specially trained for this

task. The bulls must be taken directly to the test without participating in other scheduled activities.

Hierarchical order. As previously mentioned, bulls differing in hierarchical order, sexual experience, or size should not be assessed together.

Relationship between the Numbers of Bulls and Cows

Initially, behavior tests recommended using more bulls than immobilized cows in order to reproduce the natural competition stimulus in herds, where several bulls face a cow in estrus (Blockey, 1976a). However, this situation with several bulls and one immobilized cow increases the likelihood of inhibitory factors, fights, and injuries between bulls. Therefore, the currently recommended B/C ratio is 1/1. One study using bulls with similar hierarchical order, sexual experience, and size did not observe differences in serving capacity when B/C ratios were 1/1 or 3/3 (Price & Wallach, 1991). The number of bulls and cows that participate in a test should be determined by the number of bulls to be evaluated.

Facilities

Specific facilities are needed to perform standard behavior tests, which is one of the main reasons why farmers often do not perform them.

Pens. Two pens are considered necessary—one for the development of the test and a neighboring one, where the bulls in waiting can receive the visual stimulus. When many bulls need to be evaluated, an additional pen is recommended for reassessment of those animals with an inconclusive evaluation.

Breeding crates. In the test pen, there will be as many breeding crates, 7–8 m apart, as there are cows to be immobilized. The crates must prevent lateral movement by the cows, and the crates should sit on a firm surface, preventing slipping, to allow bulls to mount comfortably and safely. Figure 1 shows a model of a crate fixed to the ground proposed by Barth (2013), for which the following measurements (in centimeters) are recommended: length, 90; width, 56; high pole, 120; and low pole, 90. In the case of small bovine breeds, the width needs to be adapted to the body size of the animals. The outer front of the V-shaped fence is intended to provide stability and prevent the bull from injuring the cow by making badly oriented mounts from the front. Another crate model, which is portable and widely used in Australia and Argentina, is presented in Figure 2. The dimensions and characteristics of this type have been described by Entwistle and Fordyce (2003).

Behavior Tests

Behavior tests must be performed by highly specialized personnel to reduce the influence of confounding factors (Petherick, 2005), which can lead to inconclusive results (Entwistle & Fordyce, 2003). Behavior tests have evolved substantially since their origin in order to predict bull reproductive behavior in herds with multiple sires. Next, we discuss the three main tests of bull reproductive behavior (i.e., serving capacity, libido, and mating ability) and describe the most relevant protocols. We also highlight the protocols that, in our opinion, are better suited for integration into reproductive and health programs on farms of any size.

Serving Capacity Test

The serving capacity test was developed by Blockey (1976a) in Australia. The test counts the number of

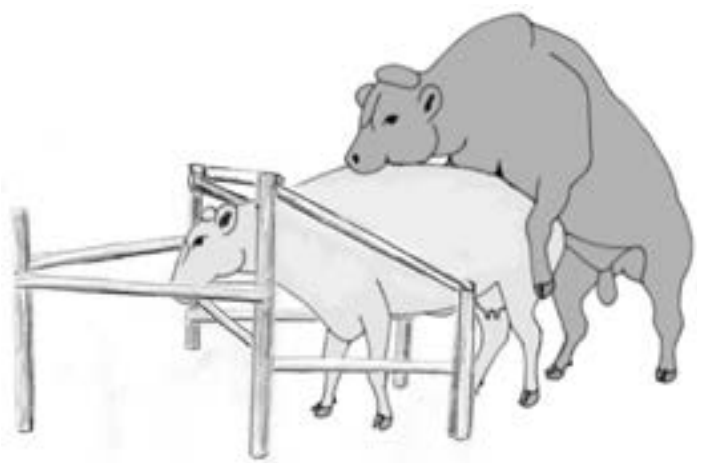

Figure 1. Fixed breeding crate for behavior reproductive tests in bulls.

Figure 2. Mobile breeding crate for behavior reproductive tests in bulls. Photo courtesy of Carlos and José de la Mata (Santa Rosa, La Pampa, Argentina; www.biotecnologiabovina.com).

services performed by a bull in a given time, so it indirectly assesses libido and mating ability also. The original design of the test involved several bulls competing to mount ovariectomized, estrogenized cows to ensure an equality of stimulus induced by the cows, at a B/C ratio of 3/5 in a 2-hectare area during 7½ hr. These procedures types are not used anymore. Studies conducted with that design showed that bulls with high serving capacity (≥ 5 matings) led to a higher pregnancy rate after the first 3 weeks of mating than bulls with medium serving capacity (1–4 matings; 77% vs. 59%), yet pregnancy rates after 6 weeks of mating were similar (90.5% vs. 88.2%; Blockey, 1978b). The bulls were used in group mating, at a B/C ratio of 3/114 in the herd. In later work, to prevent the degree of cow receptivity from affecting the number of matings, cows in estrus were immobilized in breeding crates and the test was shortened to 60 min. The serving capacity observed with this new protocol strongly correlated with the service capacity measured in a 19-day field trial (r = .90; Blockey, 1981a).

The protocol was further modified to involve immobilized cows without estrus and bulls with a previous visual stimulation of 10 min (Blockey, 1981b). These modifications allowed the test to be shortened to 20 min, with the results correlating well with those from tests lasting 40 or 60 min. More recent work experimented with a 10-min test, but in this case the timing begins not when the bull enters the test corral but when it makes its first service (Entwistle & Fordyce, 2003). Table 2 shows several serving capacity protocols, their durations, and the thresholds used to categorize bulls.

Of the protocols presented in Table 2, the one by Entwistle and Fordyce (2003) may be optimal because it takes only 10 min. Precisely because of its brevity, however, the test must be performed by highly experienced personnel and always after taking into consideration the factors already mentioned (adequate B/C ratio, criteria to select cows and bulls, cows immobilized and bulls with a previous visual stimulation time). If these conditions cannot be satisfied, the 20-min modified protocol proposed by Acuña (2019) may be more appropriate.

For both protocols, the first observed service determines the start of the test and, therefore, subsequent services are counted to categorize the bull. The recommended B/C ratio is 1/1. An option that can increase the predictive power of the test in a group system is to assess together all the bulls that will be grouped later in the field. Bulls that do not perform any service during the test must be evaluated again at the end of the day before being discarded as sires.

Bulls with high or medium serving capacity show greater libido and interest in detecting cows in estrus than bulls with low serving capacity; they also perform more mating and achieve a higher percentage of pregnancies (e.g., Blockey, 1976b; Godfrey & Lunstra, 1989; Holroyd et al., 2002; Lunstra, 1980). One study of the percentages of pregnancy at the first 3 weeks of the mating period for bulls with low, medium, or high serving capacity at a B/C ratio of 1/40 found differences to be larger (25%, 61%, and 72%, respectively) than over the entire 10-week mating period (40%, 91%, and 95%, respectively; Blockey, 1989). These results illustrate the relationship among bull serving capacity, the percentage of calves born in the first third of the calving period, and the commercial value that can be reached when all the calves are sold after a given weaning date (e.g., Diskin & Kenny, 2014; García-Paloma et al., 1992; Lesmeister et al., 1973). Because bulls of high or medium serving capacity appear not to show major differences in reproductive performance, some researchers have proposed ending the behavior test when the number of matings reaches the threshold for medium serving capacity (Barth, 2013).

The direct relationship between serving capacity and the number of matings that a bull can perform during its mating season leads us to consider the possibility of using serving capacity to help define the reproductive demand for a given bull. Reproductive demand refers to

Table 2. Duration and Assessment Thresholds of Tests of Serving Capacity.

	Service No.			
Duration (min)	High SC	Medium SC	Low SC	References
40	≥ 7	3–6	1–2	Blockey (1989)
30	≥ 3	2	1	Lunstra (1980)
20	≥ 4	2–3	1	Barth (2013); Boyd and Corah (1988)
20	2 (< 10 min)	2 (≥ 10 min)	1 (20 min)	Acuña (2019, modified)
10	≥ 3	2	1	Entwistle and Fordyce (2003)

Note: Duration is counted from when the bull enters the test corral, but the last two rows show protocols that are counted from the first service. SC = serving capacity.

the number of cows in estrus that can be assigned to the bull at the beginning of the mating season. The concept of reproductive demand, relevant cutoffs and categories, and its implementation in cattle breeding are likely to be crucial for reproductive management, yet they have never been explored in the literature.

High reproductive demand can be defined according to the Australian bull breeding soundness evaluation system, which defines a "satisfactory" bull as one that can impregnate 60% of 50 cows in estrus during the first 3 weeks of mating and 90% of these cows at the end of a mating period of 9 weeks (Fordyce et al., 2006). This definition is the same for single or group mating systems and implies the service of an average of 2.4 cows per day at least once during the first 3 weeks of the mating period.

However, recognizing that the ratio of one bull for every 50 cows in estrus at the beginning of the mating period can increase the risk of injuries in the bull and compromise the expected pregnancy rate, especially if it is used in a simple mating system, we propose the proportion of one bull for every 40 cows in estrus as the threshold to define high reproductive demand. This recommendation is in line with the recommendations of Barth (2013), Beggs (2013), and Chenoweth and Taylor (2002). On most beef farms, the usual B/C ratio is 1/20–30 (Koziol & Armstrong, 2018). Based on this proportion, we propose the threshold of less than 20 cows in estrus to define low reproductive demand and 20 to 39 cyclical cows to define medium reproductive demand.

Given these considerations, we suggest that bulls with high or medium serving capacity can be used for herds with high reproductive demand whenever they have been qualified as satisfactory in physical health and seminal assessment according to bull breeding soundness evaluation procedure. For these herds, the four evaluations must be carried out each year on all bulls. To guarantee that ejaculates have an adequate amount of spermatozoa, especially during the first third of the mating period where the number of daily services is high, a larger scrotal circumference than the breed average is recommended. It is important to optimize health and feeding conditions during the mating period to get high reproductive efficiency. This reproductive strategy will not only reduce costs because fewer bulls will be used but also accelerate genetic improvement of the herd if bulls of greater genetic merit are used.

In herds with medium reproductive demand, bulls with medium and high serving capacity and a satisfactory physical and health assessment can be used. Seminal quality can be assessed once, before the start of the 1st year of mating, and serving capacity can be assessed once, before the start of the 2nd year of mating, given the relatively constant serving capacity of a bull over the years. Indeed, the heritability of serving capacity shows 0.59 (Blockey, 1978a) and the heritability of the number of mounts 0.29 (Wade et al., 2001).

In Spain, most cattle farms have calvings throughout the year: 30.6% of the year's calvings occur in winter, 29.7% in spring, 18.4% in summer, and 21.3% in autumn (MAPAMA, 2018). The herds on these farms typically contain one bull for every 20 to 30 cows. Because the number of cows in estrus per day is less the number of assigned cows, we conclude that most bulls face low reproductive demand and therefore are underutilized. For herds with low reproductive demand, physical, health, and mating ability assessment should be performed yearly, whereas seminal assessment once before the start of the 1st year of mating; serving capacity assessment would not be necessary.

Libido Test

The serving capacity test counts only the number of services and so does not establish differences between bulls that finish the test without having performed a service and bulls that perform the same number of services. For a more precise assessment of the reproductive behavior of the bull, the libido test was proposed (Chenoweth et al., 1979). This test quantifies the number of episodes that occur with respect to the three main parameters that describe bull reproductive behavior: sexual interest, number of mounts, and number of services. It is used primarily for research purposes, such as to evaluate new stimulation factors to shorten bull reaction time or to compare the reproductive behavior of bulls differing in sexual experience or breed.

The facilities and protocol requirements necessary for the libido test are almost the same as those for the serving

Table 3. Scale and Evaluation Criteria of the Libido Test Based on Bertram, Fordyce, and McGowan (2002).

Scale	Sexual Interest (I)	Mounts (M)	Services (S)
0	0	0	0
1	1	0	0
2	2–5	0	0
3	> 5	0	0
4	> 5	1	0
5	> 5	2	0
6	> 5	> 2	0
7	> 5	0–5	1
8	> 5	> 5	1
9	> 5	> 5	2
10	> 5	> 5	> 2

capacity test. The only difference is that bulls are rated on a scale from 0 to 10 based on the number of events counted for each of the three behavior parameters mentioned previously (Bertram et al., 2002; Table 3). In its original design, the test lasted 5 min, but many bulls did not complete a service during that time (Chenoweth et al., 1979). When the test was extended to 10 min, 42% of bulls completed a service (Landaeta-Hernandez et al., 2001). Extending the test to 20 min and timing from the first mounting increased the percentage of bulls that performed a service to 83% (Bertram et al., 2002).

Based on these results, we propose performing the libido test as described by Bertram et al. (2002). For precise data recording, Entwistle and Fordyce (2003) recommend recording the time of the first mount as the beginning of the test and then recording each episode coded as a single letter (I = sexual interest, M = mounting, S = service) followed by the minute of occurrence. Each behavioral trait during the test is coded by a letter that identifies the episode and the moment when it happens. The moment of the first episode is recorded in hours:minutes, whereas the following episodes are recording only in minutes. For example, the data log for a bull that performed the first mating at 10:50 could look as follows: M (10:50) - I (53) - I (54) - M (55) - S (59) - M (03) - S (05) - S (08).

Mating Ability Test

The purpose of assessing mating ability is to verify whether a bull shows the normal chain of reflexes that will lead to successful mating. Like the tests mentioned above, this test can verify absence of abnormalities in external genitalia and in the musculoskeletal system. The mating ability test is recommended for both virgin and experienced bulls. Because this ability requires a learning phase (Boyd & Corah, 1988), the test does not last for a predetermined time. Application of the stimulation factors mentioned earlier can reduce the reaction time and test duration. In our opinion, the mating ability test must be incorporated into the usual reproductive and health program on beef cattle farms, such that all bulls are evaluated annually before the start of the mating period. For virgin bulls, this test can be the first anatomical and functional assessment of reproductive soundness. For experienced bulls, the test can detect anatomical abnormalities or injuries that occurred during the previous mating period.

Future Directions

It would be interesting to know whether, given an adequate nutritional, physical, and health stage of the bulls, the serving capacity and seminal quality of a young bull is maintained throughout the years, and specifically for how long. The libido test, because of its greater precision in assessing the reproductive behavior of the bull, could be used to test possible new stimulation factors such as the urine of a cow in heat.

Key Points for Field Veterinarians

Training veterinarians and farmers on the relevance of behavioral patterns in bulls will enhance those able to perform this kind of tests. The proposed, simplified protocol (Table 4) to perform the mating ability and the serving capacity tests presented in the current work make it easy to include these tests in the bull breeding soundness evaluation, which is performed yearly by trained veterinarians. These tests must be performed in safety chutes with nonslip surfaces, and with the support of trained workers and an appropriate number of cows available, the exact number of which will depend on the

Table 4. Behavior Tests Procedure: Instructions for Veterinarians

Staff	Minimal and specially trained staff required	
Cows	Immobilized cows in breeding crates (without estrus) Adequate body condition, size, and weight Obstetric lubricant applied into the vagina and on the perivulvar area Replace the immobilized cow if it shows signs of stress or after the 10th mount	
Stimulation factors	Visual: at least for 10 min, bulls observe other bulls under evaluation Competition: bulls group	
	Mating Ability	**Serving Capacity**
B/C ratio	Single evaluation	Group evaluation, B/C ratio: 1/1
Duration	No predetermined time	10–20 minutes
Frequency	Annually, before the start of the mating period	Once, before the start of the 2nd year of mating
Bull type	Virgin and experienced	Experienced

Note: B/C = bulls to cows.

number of bulls to evaluate. In this way, the reproductive management programs will enhance their efficiency in beef cattle farms.

Conclusion

The reproductive behavior tests of the bull (serving capacity, libido, and mating ability) were initially designed for large beef cattle farms with a group mating system. The tests have not been easily integrated into livestock practice. The present work proposes more simple and adaptable protocols for medium-sized farms, which may facilitate their integration into the bull breeding soundness evaluation procedures. This approach will improve the assessment of the reproductive potential of bulls when the bull breeding soundness evaluation methodology is used, will generate more confidence in farmers, and will boost the demand of these tests.

The serving capacity test of all bulls should be performed annually on farms with high reproductive demand, but only once just before starting the 2nd mating year on farms with medium reproductive demand. The libido test, which is the most accurate for describing bull reproductive behavior, is ideal for research aimed at explaining, simplifying, and improving the other two behavior tests. However, we do not suggest its incorporation into bull breeding soundness evaluation procedures, because of its complexity. Finally, the mating ability test should be performed annually on all bulls, regardless of their reproductive demand, because the test is simple and provides crucial information to maintain or increase reproductive efficiency of farms.

The incorporation of behavioral tests into the routine management of extensive beef herds can make owners more sensitive to their animals. The fact that the evaluation of natural behavior helps assess the herd may increase the general attention to animal welfare and natural behavior by the farmers with a positive consequence on the herd productivity and on animal well-being.

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