Selection and Management of Natural Service Sires in Dairy Herds

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Abstract

Use of natural service sires for reproductive management of dairy herds, either as the sole breeding source or as a follow-up behind artificial insemination (AI), continues to be popular for a variety of reasons, despite the risks of using sires of unknown genetic merit. There are numerous references in the literature regarding management and care of natural service sires in beef herds, but relatively few for dairy herds. Dairymen and veterinary consultants alike should be aware of the unique management factors associated with use of bulls in dairies as compared to beef herds, as well as the additional safety concerns. Management factors that should be considered when using bulls in dairies include the high calcium, high energy and relatively lower fiber rations of lactating cows, the use of potentially high risk by-product feed ingredients such as cottonseed, and the potentially harmful effects of confinement housing and concrete on estrus detection and service rate. Other considerations are general health, difference in average age of bulls being used as compared to beef herds, and the resulting issues regarding libido, and the potentially high risk of turnover in service sires as a result of the combination of these factors. The objective of this paper is to provide veterinarians with information to help dairy producers improve the management of their natural service sire programs. While this paper doesn't discuss the specific economic costs associated with use of natural service sires, it does offer suggestions to improve the efficiency of their use.

Introduction

A recent survey of California dairymen reported that despite the growth in popularity of artificial insemination (AI), 84% were using natural service sires for at least a portion of their breeding program management.[12] Although most respondents stated that they used bulls on less than 30% of their herd, approximately 19% reported that bulls were their primary means of getting cows pregnant. The 45th Annual Hoard's Dairyman Continuing Market Survey reported that respondents using bulls for reproductive management of their milking cows had remained rather steady from 1990 to 2000, with approximately 35-40% using bulls in their lactating herd and approximately 40-50% using bulls for at least part of their heifer reproductive management.[22] Based on results of these surveys and personal communications with dairymen, bull use continues to be popular for a variety of reasons, despite the risks of using sires of unknown genetic merit. (An economic evaluation of this choice for breeding management has been presented previously and will not be discussed in this paper, but will be reviewed during the general session of the 2003 AABP meeting in Columbus.[36]) Unfortunately, the vast majority of information used for making recommendations about bull selection and management is from research using beef bulls in pasture settings. Other sources of information are testimonials or experiences from dairy practitioners with clients that successfully use bulls in their breeding program. The objective of this paper is to provide veterinarians with information to help dairy producers improve the management of their natural service sire programs.

Selection of Bulls

The primary objective of the natural service sire is to locate, service, and ultimately impregnate estrual cows as quickly as possible. To perform this mission efficiently, the bull must possess good libido, adequate semen quality, and sound physical characteristics. Ideally, bulls should also have reasonable dispositions, because in the dairy environment, bulls will interact with people on a daily basis.

Location of receptive females has been shown to depend primarily on the sense of vision in pasture or range bulls.[20] Cows in late proestrus and estrus tend to form sexually active groups that are more mobile and often remain standing even while the majority of herd mates have finished eating and are resting.[55] Sexually active bulls take advantage of this social tendency of cows and rely on vision to locate and follow these groups. Bulls purchased for use as service sires should have good vision, with eyes free of evidence of old ocular lesions from infectious bovine keratoconjunctivitis.

In free stall housing, the formation of small sexually active groups is often depressed due to poor footing or crowding effects, and bulls must increasingly rely on other abilities to detect cows in estrus. In these situations, as well as after visually locating estrual females, bulls test female receptiveness by chin pressing, mounting attempts, and by nuzzling and sniffing of the perineal area. Bulls then display a set of behaviors that include head and neck extension and characteristic curling of the upper lip (flehmen reaction) that is associated with the movement of vaginal fluids and urine from the cow's perineum to the vomeronasal organ for detection of pheromones.[24,25]

Once a bull has located a female in estrus and has confirmed receptiveness by chin pressing and short mounting attempts, a full mount followed by intromission and copulation occurs in a very brief period of time (seconds). In order for copulation to occur, the bull must be able to physically support a large portion of his weight on his rear limbs, fully and freely extend his fibro-elastic penis, and gain adequate intromission to deliver the ejaculate. Bulls with sore feet, legs or back, or with traumatic injuries, a persistent frenulum, penile deviations, hair rings, or other penile or preputial abnormalities may not adequately or efficiently service cows. In addition, bulls with poor conformation/ post-legged should not be selected for breeding purposes due to increased risk of lameness over time as compared with bulls of proper conformation.

With the exception of some of the penile problems mentioned above, many of the physical traits required of breeding bulls may be evaluated with routine physical examinations. However, other traits or abilities must be investigated through the use of breeding soundness examinations (BSE), the details of which will not be covered in this paper. Suffice it to say, however, that for bulls to efficiently impregnate cows, they must possess healthy internal organs (seminal vesicles, prostate, and ampullae), as well as external sex organs (testes, epididymides, penis and prepuce), and adequate numbers of morphologically normal spermatozoa with reasonable progressive motility, all of which can be evaluated through a BSE. Scrotal circumference score standards for Holstein are similar to those described by the Society of Theriogenology for beef bulls, with an absolute minimum of 30cm and increasing minimum requirements as the bull ages. In addition, bulls should test negative for *Trichomonas foetus* and *Campylobacter fetus* subspecies *venerealis* (vibrio) before being introduced into a group of cows.

The importance of utilizing BSEs cannot be overemphasized. Results from initial exams of over 300 young dairy bulls (12-15 months of age) in Overton, California revealed that between 25-35% of bulls failed or were given deferred classification. The majority of the bulls given a deferred classification were immature. The primary reasons for bulls failing the BSE were unacceptable spermatozoal morphology (not motility), testicular problems, or internal gland problems (unpublished observations). Similar results were reported by Carson and Wenzel in 1995.[9] They examined 1,276 bulls, primarily beef bulls with a small number of Holsteins, and classified 37% as either unsatisfactory (28.9%) or deferred (8.2%). Young bulls (those less than 16 months of age) experienced a similar risk for an unsatisfactory rating, but a higher risk for deferred classification (15.1%) as compared to the group average. The main reasons given for unsatisfactory or deferred classification were unacceptable spermatozoal morphology, insufficient scrotal circumference, and physical problems, including eye lesions, lameness, and internal and external sex organ lesions. Another larger study involving 3,648 yearling beef bulls showed a lower failure or deferred risk of 23.8%.[29] In these beef bulls, the most commonly cited reasons for failure again involved testicular problems and sperm morphology, with internal gland problems being less commonly cited.

A BSE that is properly performed is extremely valuable in identifying potential breeding problems, but is limited since the BSE does not evaluate a bull's libido, a highly desirable and measurable behavioral trait. Libido is most often evaluated through the use of serving capacity tests that evaluate the number of services attempted by bulls during a set period of time using restrained, non-estrual females at predetermined bull:female ratios.[5] Unfortunately, there is considerable variation between bulls and between tests, and while there appears to be a strong genetic component to libido, there does not appear to be any relationship between scrotal circumference and libido.[15]

Often dairymen purchase very young bulls (9-11 months of age) and place them with heifers in a "clean-up" pen. This practice might possibly be beneficial to the sexual development of young bulls, as it has been shown that rearing young bulls in all-male groups may delay expression of heterosexual behavior.[13] How early should bulls be expected to display normal breeding behavior, including reliably servicing estrual females? One study that examined Holstein and Brown Swiss bulls found that puberty, defined as the age at which bulls produced ejaculates containing at least 50 x 10^6 spermatozoa with a minimum of 10% progressive motility, was reached at approximately 11 months.[26] Progressive motility, sperm concentration, and scrotal circumference increased through 18 weeks post-puberty, however, suggesting that fertility of young bulls would improve with time and by 14-15 months of age, breeding performance should become more reliable.

Another study involving yearling natural service bulls found that young sires were less fertile than older bulls (two-to-three yrs old), despite equivalent mating activity.[37] In this report, no differences were found in the number of services or percent of estrual heifers serviced. Nevertheless, the yearling bulls produced fewer pregnancies, indicating lower fertility for young bulls as compared to two-to-three year-old bulls.

Despite the lower fertility of yearling bulls, advantages to using them as compared to older service sires include higher predicted genetic merit (due to improvement in average genetic potential with each successive generation), calmer dispositions, lower risk for transmission of venereal diseases, lower risk of musculo-skeletal disorders, more moderate body condition, and lower costs associated with purchase and maintenance. Dairy bulls are usually reared in close contact with people and therefore, often fail to develop appropriate avoidance behavior that is more common in range beef bulls. Consequently, bulls may need to be culled early to avoid confrontational or aggressive behavior that usually increases with age. Bulls that are constantly housed with lactating cows also gain weight rapidly and suffer an increased risk of acidosis and laminitis due to the interaction of the lactating cow ration and housing (especially concrete floors). Rapid weight gain can quickly lead to very heavy or fat bulls that may injure cows during mounting. Bulls are often purchased for two-to-three times final market value (salvage value;price/lb), and if bulls are culled prematurely due to weight, libido, disposition, or lameness, inventory and procurement costs rise. Consequently, the current recommendation is to introduce young bulls (14-15 months of age) with a moderate body condition score into the breeding herd and maintain these bulls for no longer than 12 months.

Management of Bulls: Stocking Density

Producers often ask: "How many bulls do I need?" or "How many cows can I put with a bull?" Unfortunately, the answer is not as clear as it is in the beef industry. With beef cows, the standard recommendation for bull:cow stocking density is one bull per 20-30 non-pregnant females.[14] However, the actual ratio used has varied from 1:10 to 1:60+, depending on the ages of the bulls being used and whether or not synchronization strategies were employed prior to moving the cows to the bull. Rupp *et al* stated that low ratios made inefficient use of bulls.[44] Instead, they suggested, good reproductive efficiency could be obtained with ratios of 1:44 and 1:60. At these higher working ratios, Rupp *et al* reported over 70% of the beef heifers used were marked by more than one bull during estrus.

Regarding stocking density, dairy bulls are at a competitive disadvantage relative to beef bulls due to housing environment (concrete surfaces), younger average age of bulls in use, lower apparent libido, possibly lower fertility of lactating cows, and rations consumed (cottonseed products that contain gossypol). Champagne *et al* found that 53% of California dairymen surveyed used bulls at the ratio of 1 bull per 30 or fewer non-pregnant cows. The most common stocking ratio listed was 1:20 to 1:25 total cows in the pen. At this ratio, it is very likely that 30-50% of the cows were either already diagnosed pregnant or were too early pregnant to determine. If so, the actual stocking ratio would then be approximately 1:15 non-pregnant cows.

Why do dairies use such a low stocking density? The answer to this question is most likely a combination of factors. First, most dairies routinely use young bulls that may not have the service capacity of older bulls. Second, very few dairies perform BSEs and thus, have no knowledge of fertility of individual bulls. (The solution to this problem has traditionally been "add more bulls.") Third, many dairies have cows housed in free stall facilities, and many of these barns, especially older, poorly designed facilities, have slippery footing and may be overcrowded. Bulls may become less efficient breeders in barns with slippery or unstable flooring.[16] As previously mentioned, bulls rely in large part on visual cues (sexually active groups of cows standing around) and in free stall barns, cows may be less able to form these groups. Therefore, bulls may have to rely on individual cow identification (attempted mounts and smell) to locate cows in estrus. Identification of estrual females by these methods is less efficient, thus more bulls are required per pen.

The optimal stocking ratio for dairy herds is not known, but probably differs depending upon housing environment and level of management. For dry lot or pasture dairies, if we assume that dairies will continue using young bulls, the proper ratio is most likely approximately one healthy and fertile bull per 20-25 non-pregnant cows, depending upon whether or not the cows have been synchronized before entering the pen. For free stall dairies, more bulls are likely required and a ratio of 1:15-20 non-pregnant cows is suggested. Nevertheless, it must be remembered that bulls exhibit dominance patterns much like other animals, including cows. In general, older bulls are more dominant and may attempt to monopolize certain females.[16] Chenoweth has suggested that dominance and libido may be negatively correlated and that a dominant bull (or bulls) could depress herd fertility by preventing other bulls from serving cows.[15] In addition, larger, more dominant cows may intimidate young immature bulls and cause them to become shy breeders. Finally, lame bulls often cannot move around the pen to locate cows or mount adequately to service cows efficiently. In each of these cases, the *effective* stocking ratio may differ from the numerical stocking ratio.

Management of Bulls: Diet

Traditionally, bulls have been either turned in with the cows, or cows have been hand-mated by bringing them to the bull pen individually as needed. When bulls were housed individually, diet was less of a concern because bulls could be fed appropriately. Now however, bulls are often housed with high-producing cows. Consequently, bulls consume the same ration as lactating cows, often with disastrous consequences.

There are several concerns with bulls eating lactating cow diets. First, rations for lactating cows typically contain 0.76-0.80 MCal NEL/lb of dry matter and 16-18% (or more) crude protein. The nutritional requirements of bulls are closer to those of dry cows.[34] Current lactating cow rations provide two-to-three times more metabolizable protein and energy than bulls need for maintenance and growth. Bulls consuming lactating cow rations ingest enough protein and energy for high rates of daily gain, leading to overconditioning, which in turn, may lead to fertility, testicular thermoregulatory, and libido problems. In addition, the combination of concrete housing surfaces and an abundance of rapidly fermentable carbohydrates can lead to laminitis, lameness, and premature culling.

Another dietary concern that has recently received much attention is the feeding of cottonseed products and, more specifically, the toxic agent gossypol. Gossypol is a toxic, polyphenolic component found naturally within pigment glands of nearly all varieties of cotton, and provides a defense mechanism for the plant against insects and pests. Gossypol can be found in two forms: a) free, or b) bound to a protein. The bound form of gossypol is less toxic than the free form. Gossypol exists naturally as a mixture of two stereoisomers called (+) gossypol and (-) gossypol, with (-) gossypol being more toxic.[7] The gossypol content of whole cottonseed and cottonseed meal varies according to the species and variety of cotton, with Pima cottonseed having a higher free gossypol content and a higher percentage of (-) gossypol than does Upland cottonseed.[38,39] Cottonseed meal, a feedstuff high in protein, varies in gossypol content depending upon extraction method. The solvent method of oil extraction ruptures the pigment glands, allowing the release of gossypol, whereas cottonseed meal resulting from mechanical extraction of oil contains less gossypol.[30] Finally, temperature and rainfall during the growing season also influence the gossypol content of whole cottonseed and cottonseed meal.[30,40]

Monogastrics and preruminants readily absorb free gossypol, leading to gossypol toxicity.[40] In contrast, healthy, mature ruminants are able to detoxify free gossypol through binding with proteins in the rumen.[11] Nevertheless, free gossypol intake may overload this mechanism, leading to deleterious effects on reproduction, especially in bulls. Cows appear to be relatively resistant to reproductive effects of gossypol ingestion.[40] The rate of passage also must be considered, as cattle on high-concentrate rations have a faster rate of passage that may permit gossypol to pass through the rumen unbound.[19,30]

Cottonseed products are common feedstuffs in total mixed rations for lactating dairy cows. Whole cottonseed is the most widely used in dairy rations, as it provides a good source of protein, fiber, and fat. A general recommendation is to limit whole cottonseed to less than 12 % of the total mixed ration dry matter, and less than 8 lb (3.6 kg) (as fed) per lactating cow per day.[21] Considering that whole cottonseed may contain 0.01% to 1.7% free gossypol content (Pons *et al*, 1953; Puschner, 2000), sampling and chemical analysis of all cottonseed products is the best management practice prior to ration formulation for all classes of cattle.[38,39] In whole cottonseed, nearly all of the gossypol exists in the free form; therefore, free gossypol and total gossypol values should be the same (Pons *et al*, 1953). For further information regarding sampling, laboratory analyses, and interpretation of results, see Rogers *et al.*[42]

Risco *et al* reported that Brahman bulls fed a ration including 6.05 lb (2.75 kg) of cottonseed meal (8.2 g of free gossypol per day) exhibited a lower percentage of normal spermatozoa compared with controls (49 ± 8 % vs. 83 ± 3.2 %) by week five of the study.[41] Beginning with week three, treated bulls exhibited an increased proportion of sperm midpiece abnormalities in ejaculates collected by electroejaculation. By week nine, depressed sperm motility was evident in treated bulls. After slaughter (during week 12), sperm production rates (daily and per gram of testicular parenchyma) were estimated through histological analyses. Treated bulls had lowered daily sperm production and lower sperm production per gram of parenchyma.[17] In contrast, Cusak and Perry reported that Hereford bulls fed a ration containing whole cottonseed to provide 7.6 to 19.8 g of free gossypol daily exhibited no significant sperm abnormalities.[18] These same researchers theorize the mineral content of the drinking water may have allowed for mineral binding of free gossypol, which would explain the lack of an effect of gossypol intake on sperm morphology in their study.

Rogers *et al* recommend that free gossypol intake should be limited to 91 mg/lb (200 mg/kg) for rations containing cottonseed meal and 409 mg/lb (900 mg/kg) for rations containing whole cottonseed for beef breeding bulls.[42] A mature dairy bull fed a ration containing whole cottonseed with a recommended dry matter intake of 28.6 lb (13 kg) results in the potential intake of nearly 12 g of free gossypol per day (900 x 13 = 11,700 mg x .001 = 11.7 g gossypol per day).[34] Unfortunately, it is not definitively known whether this amount is detrimental to bull fertility. But, the appearance of sperm midpiece abnormalities in Brahman bulls fed cottonseed meal coupled with sperm midpiece abnormalities as reported in gossypol-treated rats, hamsters and monkeys gives evidence that this abnormality appears to be specific to gossypol.[23,35,41,46] While the effect of gossypol on bull fertility is somewhat controversial, special attention should be paid to the level of cotton products in the lactating cow ration, especially when natural service sires are consuming this ration.

Another nutritional concern for bulls is excessive calcium intake. The requirement for calcium in 1200 to 1300 lb (545-591 kg) bulls is only about 15-20 g/day.[34] However, diets for high-producing cows may contain 0.6 to 1.0% calcium. Consequently, with dry matter intake of 20 pounds (9 kg), bulls on these rations may easily consume 80+ grams per day. With high levels of calcium intake, lameness due to bone lesions in the spine, pelvis, and coxo-femoral joint is possible.[16]

Management of Bulls: Increasing Longevity and Reproductive Efficiency

As previously mentioned, bulls are most commonly housed along with lactating cows, and over time, libido and fertility can diminish. The interaction of concrete flooring and rations high in energy, protein, calcium, and possibly gossypol increase the risk of premature culling, lameness, and reduced reproductive efficiency. In addition, after a period of time with one group of females, bulls tend to become disinterested, and exhibit reduced libido. Consequently, reproductive efficiency can diminish. Introducing new females into a bull's territory can stimulate an increased desire to copulate. This stimulation of sexual behavior is called the Coolidge effect, and is also known to occur in bees, mice, rats, sheep, rhesus monkeys, and yes, even humans.[2,24]

One strategy that capitalizes on the Coolidge effect and has other benefits is the use of a bull rotation system. There are two basic forms of bull rotational management. The first involves two separate groups of bulls; one group is working and one group is "resting". Typical rotation intervals are two-to-three weeks between pen changes. The non-working bulls are housed together and fed a ration that is lower in energy, protein, calcium, and gossypol than the lactating cow ration, and is usually much cheaper. Of course, abrupt changes from one ration to another require that the rations be somewhat similar to avoid increased risk of acidosis upon return to the lactating cow ration. One solution to this problem has been to feed the close-up heifer ration to these resting bulls. Obviously, this strategy requires twice as many bulls as well as a separate pen for housing resting bulls. Nevertheless, the working-resting bull rotation includes the benefits of lower rate of weight gain, decreased exposure to cottonseed products, reduced risk of lameness due to time off concrete, and improved libido due to time spent away from cows. Other benefits include increased probability of detecting lame or problematic bulls earlier in the course of disease as a result of moving bulls, and of having a "surplus" of bulls available to immediately replace a bull that is discovered to be injured or lame.

The second option involves only one group of bulls that is rotated from one breeding pen to the next. This option maintains the benefit of introducing bulls into a new group of cows every two-to-three weeks (Coolidge effect), but loses the benefit of time off concrete and changes in the ration. A possible compromise between these two options might be an extra group of bulls that contains the same number of bulls as found in a typical breeding pen. In this case, bulls can be rotated as usual, but only get a rest every three-to-six rotations, depending upon the number of breeding pens that the dairy employs.

Management of Bulls: Heat Stress

While most producers employ heat stress abatement strategies for lactating cows, we must not forget about the major effects that heat stress may have on bulls. As homeotherms, bulls strive to maintain their body temperature at a constant level of 101.1°F to 102.2°F (38.4°C to 39.0°C) through conduction, convection, radiation, and evaporation. When bulls are used for breeding management, both working and resting bulls should be provided with appropriate cooling strategies such as shades, fans, and sprinklers. For, just as with cows, if bulls fail to effectively dissipate heat, there is an increase in body temperature, resulting in negative effects on bull performance.

During heat stress conditions, inherent male thermoregulatory mechanisms such as the pampiniform plexus, sweat glands, and relaxation of the external cremaster muscle, attempt to maintain scrotal and testicular temperature below body temperature. The internal scrotal temperature for bulls ranges from 91.4°F to 94.1°F (33°C to 34.5°C), with small increases in testicular temperature causing disturbances in spermatogenesis.[54] The adverse effects of elevated temperatures on bovine spermatogenesis have been well documented and consist of impaired efficiency of spermatogenesis, as reflected by increased sperm abnormalities, and reduced sperm output and viability.[10,27,32,43,48] Fertile bulls have more viable sperm and a consistently lower incidence of morphologically abnormal sperm than infertile or subfertile bulls.[4,45,50]

Vogler *et al* studied the effect of 48-hour scrotal insulation on spermatozoal viability (motility and acrosomal integrity) and morphology in Holstein bulls.[52,53] The purpose of the scrotal insulation was to mimic a mild heat stress event that would interfere with testicular thermoregulation. The experiment was conducted during three periods (June, October and February), and ambient temperature and relative humidity ranged from 23.2°F to 92.7°F (– 4.9°C to 33.7°C) and 29.7 to 93.3%, respectively. Testicular surface temperatures ranged from 91.9°F to 97.5°F (33.3°C to 36.4°C), with a mean of 94.6°F (34.8°C). Every three days during the study, two ejaculates were collected in succession by artificial vagina. Three periods of semen collection were defined: Period 1 (pre-insult or control) consisted of ejaculations collected on days –6 to 0; Period 2 (post-insult, sperm present in the epididymis or rete testis at the time of scrotal insult) consisted of ejaculations collected on days +3 to +9; and Period 3 (post-insult, cells undergoing spermatogenesis at the time of scrotal insult) consisted of ejaculations collected on days +12 to +39 when the experiment was terminated. Period 1 and 2 did not differ in sperm motility and morphology. However, total sperm abnormalities increased and sperm motility decreased in period 3 compared to period 1. Sperm motility was depressed between 10 to 20 percentage points, and was most apparent on days +15 to +18 after insult. Abnormal sperm content increased beginning on day +12, peaked at day +18, and persisted longer than the depressed motility. At the termination of the study on day +39, the ejaculate content of abnormal sperm was approaching pre-insult levels. Although bulls varied in the type of abnormal spermatozoa produced and in magnitude of response, specific abnormalities appeared in ejaculates in a predictable chronological sequence following scrotal insult on day 0. The sequence was: decapitated sperm, (days +12 to +15); diadem, (day +18); pyriform and nuclear vacuoles, (day +21); knobbed acrosome, (day +27); and dag defect (abnormal axonemal structure), (day +30).

The effects of testicular heat stress on semen quality reported by Vogler *et al* generally relate to impaired sperm transport and fertilizing ability, but not to the genetic material (chromatin) contained by the sperm. McCosker reported that abnormally shaped sperm heads from subfertile bulls contain structurally abnormal chromatin.[31] Karabinus *et al* utilized cryopreserved semen from the studies of Vogler *et al* to determine whether heat stress induced by scrotal insulation detrimentally affected the chromatin structure of subsequently ejaculated sperm.[28] They concluded that elevated scrotal temperatures adversely affected both epididymal sperm (sperm collected in period 2 as defined by Vogler *et al*) and testicular sperm (sperm collected in period 3 as defined by Vogler *et al*) by reducing sperm chromatin stability. Acevedo *et al* also applied a 48-hour scrotal insult to Holstein bulls and reported that sperm that appear normal in conformation, but are found in ejaculates exhibiting heat-induced morphological sperm damage, tended to exhibit reduced sperm chromatin stability.[1] These results provide evidence that damage to chromatin integrity extends beyond morphologically abnormal sperm. Sperm chromatin damage would likely lead to incompetence of the fertilizing sperm in sustaining the embryo.

The thermal insult achieved by Vogler *et al* is likely similar to heat stress observed during the summer and early fall in regions where the temperature-humidity index (THI) is routinely above 72.[52,53] The impact of heat stress on dairies utilizing natural service may be devastating as impaired cow fertility is combined with decreased bull fertility, resulting in unacceptably low pregnancy rates.[3] Niles and Risco examined computer records of three California dairy herds following an especially hot summer and found that fertility dropped for both AI and natural service-bred cows.[33] The drop in natural service bull fertility is due to decreased motility and increased sperm abnormalities, and reduced chromatin stability.[1,28,52,53] Furthermore, it is apparent that natural service bulls may have decreased fertility for at least six weeks after heat stress. Therefore, in addition to providing heat stress abatement for lactating cows, dairies utilizing natural service should also ensure that bulls have access to these same cooling applications to help minimize the drop in fertility that is usually observed during heat stress conditions.

Management of Bulls: Preventive Medicine

Proper management of bulls is a critical component of the herd health program of dairies that use natural service because of the economic implications of sub-fertile bulls. Natural service sires comprise another herd of cattle, similar to heifers or dry cows, and should be managed as a separate group of animals in order to meet their specific requirements. Management considerations for the prevention of infectious diseases and lameness should be carefully planned and implemented. However, in contrast to beef cattle, published recommendations for bull management strategies in dairy cattle are limited.

Bulls should receive the same routine screening, vaccination and deworming programs as cows (except of course, brucellosis and trichomoniasis). Bulls should be screened for bovine viral diarrhea (BVD) status and not introduced into the cow herd if persistently infected, since bulls may rapidly spread BVD virus. In southern portions of the U.S., Brahman and Brahman-cross bulls are sometimes used by dairymen, especially with virgin heifers, to reduce dystocia-related problems. Caution should be used when using cholinesterase-inhibitor insecticides in Brahman and Brahman-cross bulls, because they are less tolerant to these compounds.

Control of venereal diseases is essential to the successful use of natural service sires. A common recommendation is that cows be vaccinated for vibriosis at least three weeks prior to bull exposure and should receive a booster at six month intervals. However, success has also been reported with vaccinating only the bulls. Vasquez, *et al* showed that vaccination of bulls with the oil-adjuvant *Vibrio* vaccine (Vibrin®, Pfizer Animal Health) is a very effective preventive measure and has some success as a treatment.[51] Commonly, this vaccine is used in bulls at a dose that is twice that of cows and should only be used in this manner in herds that do not purchase cows, currently do not have a *Vibrio* problem, and routinely test their bulls. Vaccination for trichomoniasis, which is not commonly used in breeding cows, should not be used in bulls. Instead, all bulls should be tested for trichomoniasis during the BSE and culled if positive.

Lameness in natural service bulls can be a major health problem with serious economic impacts. Predisposing factors for lameness include conformation, diet, and housing (standing on concrete). The most common causes of lameness in bulls reported by veterinarians working with natural service dairy herds include laminitis, arthritis, interdigital fibromas, foot rot and hairy heel wart.[8] Because of the pressure distribution in the claw while standing, bulls are particularly susceptible to excessive wear of the outside wall of the lateral claw of the hind legs, similar to cows. Excessive wear of the claw predisposes bulls to sole damage that may result in hemorrhages, ulceration and sub-solar abscesses. Lameness can affect herd fertility by affecting the ability of the bull to follow and mount cows that are in estrus.

Secondly, it has been suggested that pain from lameness can result in testicular degeneration affecting sperm quality.[8] Bulls should be examined while standing and traveling on hard surfaces as described in cows.[49] In addition, bulls should also be monitored during mounting for pain and reluctance to breed. To prevent lameness in natural service sires, it is imperative to include bulls in the herd hoof-trimming program and periodically rest them to provide relief from hard surfaces. Current recommendations for hoof trimming dairy cows include a minimum of once per year, but with longer lactations for many cows, optimum results should be obtained with trimming performed every four-to-six months for the majority of cows.[6,47] Bulls are exposed to the same concrete alleys and the same high-energy rations as lactating cows, and thus would be expected to experience similar benefits of hoof trimming. Other keys to improving the longevity and breeding efficiency of bulls in dairy herds include heat-stress abatement strategies.

An example of an efficient and practical bull management program developed by the Aurora Dairy Corporation of Colorado is shown below and is printed with their permission.

All new bulls:

1. All purchased bulls should be mouthed for age. Bulls greater than 15 months of age should be rejected. All bulls must weigh 700- 800 lbs. (318.2 – 363.6 kg) at the time of purchase and each bull should have its own unique identification number.
2. Perform a Breeding Soundness Examination and test for trichomoniasis
3. Vaccinations:
   - IBR/BVD/PI3 & BRSV (Modified Live Vaccine) + 5-way Lepto. Repeat initial vaccination in three weeks.
   - *Clostridium* 8-way
   - *Vibrio* (oil adjuvant): revaccinate with *Vibrio* vaccine every three months.
4. Parasite Control:
   - Deworm and delouse: repeat three weeks after first application

Current breeding bulls (exposed to lactating cows)

1. All bulls must have a complete BSE every six months. After initial processing and clearance, bulls should be used for six months. After six months bulls should be re-tested and if satisfactory, they are used for another six months, after which the bull is culled.

2. No bull is to be used in service for more than 12 months.

3. Bulls are revaccinated every three months for *Vibrio* and the other vaccines are boostered in concert with the lactating herd.

4. Bulls must be checked daily for lameness and other health disorders. If a bull is lame, he should be removed from the cow herd and treated accordingly. Lame bulls should be replaced immediately by a sound bull.

5. Keep a minimum of 10 bulls in the resting pen ready to relieve any ill or lame bull. (These additional "bulls-in-reserve" represent about 10% of the normal working population.)

6. Monitor attitude daily. Any bull that becomes aggressive or difficult to handle must be culled as soon as possible.

7. Check daily to make sure that bulls are in the correct pens and that bull-to-cow ratios are correct. Bulls should be rotated after 14 days. Maintain one bull for every 25 open cows in each pen. After each palpation week, re-evaluate these ratios and adjust accordingly.

8. Resting bulls receive the lactating cow total mixed ration (TMR) refusals (tends to be higher in fiber and contains less cottonseed and energy as the original feed, but yet decreases the risks associated with wholesale ration changes).

Summary

The use of natural service sires for reproductive management continues to be a popular option for many dairies, despite the variety of problems that may arise. Reproductive efficiency of dairy cattle depends on the ability to deliver quality semen to the correct cow in a timely and efficient manner. Each form of semen delivery, whether natural service or artificial insemination, has unique advantages and disadvantages depending upon the herd's management abilities and goals, as well as the facilities. Veterinarians are often asked for recommendations regarding the management of bulls and how to improve the reproductive efficiency of their clients' dairies. This paper was not intended to either encourage or discourage the use of natural service sires on dairies, but rather, was meant to offer suggestions for improved management of bulls to achieve better reproductive success, should a decision be made to utilize natural service.

References

1. Acevedo N, Bame J, Kuehn LA, Hohenboken WD, Evenson, DP, Saacke RG: Sperm chromatin sturcture assay (SCSA) and sperm morphology. *Proc 19th Tech Conf on AI and Reprod*, National Association of Animal Breeders, Columbia, MO, pp 84-90, 2002.
2. Alcock J: Sexual selection and male competition. *Animal Behavior, An Evolutionary Approach*, 3rd ed, Sinauer Associates, Inc, pp 353-353, 1984.
3. Badinga L, Collier, RJ, Thatcher WW, Wilcox CJ: Effects of climatic and management factors on conception rate of dairy cattle in subtropical environment. *J Dairy Sci* 68:78-85, 1985.
4. Barth AD, Oko J: *Abnormal morphology of bovine spermatozoa*. Ames, IA, Iowa State University Press, pp 145-151, 1984.
5. Blockey MA: Serving capacity - a measure of the serving efficiency of bulls during pasture mating. *Therio* 6:393-401, 1976.
6. Burgi K: Maintenance trimming: why, when, and how? *Proc North Amer Vet Conf* 14:1-2, 2000.
7. Calhoun MC: Understanding and managing gossypol in cattle diets. *Proc Southwest Nutrition and Management Conf,* University of Arizona, Tempe, pp 17-26, 1995.
8. Carson RL: Lameness in breeding bulls. *Proc North Amer Vet Conf* 14:3-4, 2000.
9. Carson RL, Wenzel JG: Over a thousand BSE's using the new form. *Proc Soc for Therio Annual Meeting*, September 13-15: pp 65-72, 1995.
10. Cassady RB, Myers RM, Legates JE: The effect of exposure to high ambient temperature on spermatogenesis in the dairy bull. *J Dairy Sci* 36:14, 1953.
11. Casteel SW: Reproductive toxicology. *Current Therapy in Large Animal Theriogenology*, R.S. Youngquist, ed, Philadelphia, PA, WB Saunders, pp 392-399, 1997.
12. Champagne JD, Kirk JH, Reynolds JP: Bull management practices on California dairies: implications for education and veterinary services. *Proc 15th Annual U.C Davis Fall Symp*, September 15, 2002.
13. Chenoweth PJ: Libido and mating behavior in bulls, boars and rams: a review. *Therio* 16:155, 1981.
14. Chenoweth PJ: Bull behavior, sex drive and management. *Factors Affecting Calf Crop*, Fields MJ; Sand RS, (eds): CRC Press, Inc, pp 319-330, 1994.
15. Chenoweth PJ: Bull libido/ serving capacity. *Vet Clin North Am Food Anim Pract,* 13:2, 331-344, July 1997.
16. Chenoweth PJ, Larsen RE: Selection, use and management of natural service bulls. *Large Dairy Herd Management,* Van Horn HH; Wilcox CJ, (eds): American Dairy Science Association, pp 209-218, 1992.
17. Chenoweth PJ, Risco CA, Larsen RE, Velez JS, Tran T, Chase CC, Jr: Effects of dietary gossypol on aspects of semen quality, sperm morphology, and sperm production in young Brahman bulls. *Therio* 42:1-13, 1994.
18. Cusack PM, Perry V: The effect of feeding whole cottonseed on the fertility of bulls. *Aust Vet J* 72:463-466, 1995.
19. Danke RJ, Panciera RJ, Tillman AD: Gossypol toxicity studies with sheep. *J Anim Sci* 24:1199, 1965.
20. Geary TW, Reeves JJ: Relative importance of vision and olfaction for detection of estrus by bulls. *J Anim Sci* 70:2726-2731, 1992.
21. Harris B: Purchasing, storing, and using commodity feedstuffs. *Large Dairy Herd Management,* Van Horn HH; Wilcox CJ, (eds): American Dairy Science Association, pp 373-381, 1992.
22. Hoard's Dairyman. Hoard's Dairyman Continuing Market Survey, 2001.
23. Hoffer AP, Agarwal A, Meltzer P, Herlihy P, Naqvi RH, Lindberg MC, Matlin SA: Ultrastructural, fertility, and spermicidal studies with isomers and derivatives of gossypol in male hamsters. *Biol Reprod* 37:909-924, 1987.
24. Houpt KA: Sexual behavior. *Domestic Animal Behavior for Veterinarians and Animal Scientists*, ed 3, Ames, IA, Iowa State University Press, pp 124-131, 1998.
25. Jacobs VL, Sis RF, Chenoweth PJ: Tongue manipulation of the palate assists estrus detection in the bovine. *Therio* 13:353-356, 1980.
26. Jimenez-Severiano, H.: Sexual development of dairy bulls in the Mexican tropics. *Therio* 58:921-932, 2002.
27. Johnston JE, Naelapaa H, Frye Jr B: Physiological responses of Holstein, Brown Swiss, and Red Sindhi crossbred bulls exposed to high temperatures and humidities. *J Anim Sci* 22:432, 1963.
28. Karabinus DS, Vogler CJ, Saacke RG, Evenson DP: Chromatin structural changes in sperm after scrotal insulation of Holstein bulls. *J Androl* 18:549-555, 1997.
29. Kennedy SP, Spitzer JC, Hopkins FM, Higdon HL, Bridges WC Jr: Breeding soundness evaluations of 3,648 yearling beef bulls using the 1993 Society for Theriogenology guidelines. *Therio* 58:947-961, 2002.
30. Kerr LA: Gossypol toxicosis in cattle. *Comp Contin Educ Pract Vet* 11:1139-1146, 1989.
31. McCosker PJ: Abnormal spermatozoan chromatin in infertile bulls. *J Reprod Fertil* 18:363-365, 1969.
32. Meyerhoeffer DC, Wettemann RP, Coleman SW, Wells ME: Reproductive criteria of beef bulls during and after exposure to increased ambient temperature. *J Anim Sci* 60:352-357, 1985.

33. Niles D, Risco CA: Seasonal evaluation of artificial insemination and natural service pregnancy rates in dairy herds. *Comp Contin Educ Pract Vet* April:S44-S48, 2002.
34. NRC. *Nutritional Requirements of Beef Cattle*, ed 7. 2000.
35. Oko R, Hrudka F: Segmental aplasia of the mitochondrial sheath and sequelae induced by gossypol in rat spermatozoa. *Biol Reprod* 26:183-195, 1982.
36. Overton MW: Economics of bull use on dairies. *Proc of the 15th Annual U.C Davis Fall Symp*, September 15, 2002.
37. Pexton JE, Farin PW, Gerlach RA, Sullins JL, Snoop MC, Chenoweth PJ: Factors affectiong mating activity and pregnancy rates with beef bulls mated to estrus synchronized females. *Therio* 32:705, 1990.
38. Pons Jr WA, Hoffpauir CL, Hooper TH: Gossypol in cottonseed: Influence of variety of cottonseed and environment. *J Agric Food Chem* 1:1115, 1953.
39. Puschner B: Feeding cottonseed to dairy cattle. *California Animal Health and Food Safety Laboratory System Bulletin,* 2000.
40. Randel RD, Chase CC Jr, Wyse SJ: Effects of gossypol and cottonseed products on reproduction of mammals. *J Anim Sci* 70:1628-1638, 1992.
41. Risco CA, Chenoweth PJ, Larsen RE, Velez JS, Shaw N, Tran T, Chase Jr CC: The effect of gossypol in cottonseed meal on performance and on hematological and semen traits in postpubertal brahman bulls. *Therio* 40:629-642, 1993.
42. Rogers GM, Poore MH, Paschal JC: Feeding cotton products to cattle. *Vet Clin North Am Food Anim Pract* 18:267-294, 2002.
43. Ross AD, Entwistle KW: The effect of scrotal insulation on spermatozoal morphology and the rates of spermatogenesis and epididymal passage of spermatozoa in the bull. *Therio* 11:111, 1979.
44. Rupp GP, Ball L, Shoop MC, Chenoweth PJ: Reproductive efficiency of bulls in natural service: effects of male to female ratio and single- vs multiple-sire breeding groups. *J Am Vet Med Assoc* 171:639-642, 1977.
45. Saacke RG: Components of semen quality. *J Anim Sci* 55;Suppl 2:1-13, 1982.
46. Shandilya L, Clarkson TB, Adams MR, Lewis JC: Effects of gossypol on reproductive and endocrine functions of male cynomolgus monkeys (*Macaca fascicularis*). *Biol Reprod* 27:241-252, 1982.
47. Shearer JK: Managing lameness for improved cow comfort and performance. *Proc 6th Western Dairy Management Conf*, Reno, NV, pp 167-177, 2003.
48. Skinner JD, Louw GN: Heat stress and spermatogenesis in Bos indicus and Bos taurus cattle. *J Appl Physiol* 21:1784-1790, 1966.
49. Sprecher DJ, Hostetler DE, Kaneene JB: A lameness scoring system that uses posture and gait to predict dairy cattle reproductive performance. *Therio* 47:1179-1187, 1997.
50. Sullivan JJ: Morphology and motility of spermatozoa. 286-328, 1978.
51. Vasquez LA, Ball L, Bennett BW, Rupp GP, Ellis R, Olson JD, Huffman MH: Bovine genital campylobacteriosis (vibriosis): vaccination of experimentally infected bulls. *Am J Vet Res* 44:1553-1557, 1983.
52. Vogler CJ, Bame JH, Dejarnette JM, McGilliard ML: Effects of scrotal insulation on viability characteristics of cryopreserved bovine semen. *Therio* 40:1207-1219, 1994.
53. Vogler CJ, Saacke RG, Bame JH, Dejarnette JM, McGilliard ML: Effects of scrotal insulation on viability characteristics of cryopreserved bovine semen. *J Dairy Sci* 74:3827-3835, 1991.
54. Wildeus S, Entwistle KW: Spermiogram and sperm reserves in hybrid Bos indicus X Bos taurus bulls after scrotal insulation. *J Reprod Fertil* 69:711-716, 1983.
55. Williamson NB, Morris RS, Blood DC. Cannon CM, Wright PJ: A study of oestrous behaviour and oestrus detection methods in a large commercial dairy herd. II. Oestrous signs and behaviour patterns. *Vet Rec* 91:58-62, 1972.

Abstract

UK Field Experiences with a Dry Period Internal Teat Sealer in a Positive Control Study

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The efficacy of a non-antibiotic internal teat sealer based on bismuth subnitrate at preventing new dry period mtra-mammary infections was compared to the UK's market leading antibiotic dry cow therapy in a 500 cow, 16 farm study in SW England. Cows likely to be uninfected with major pathogens at drying off were selected using historical data (all routine cow level somatic cell counts <200,000 cells/ml and no cases of clinical mastitis during the preceding lactation). The new dry period infection rate and number of cases of clinical mastitis during the first 100 days of the next lactation were monitored.

Compared to the antibiotic tube, animals that received the teat sealer acquired significantly fewer new dry period infections caused by *E. coli,* all *Enrerobacteriuceue* and all major pathogens. There were no significant differences in the number of infections caused by any other major pathogen. Quarters that acquired a new dry period infection were at significantly greater risk of suffering a case of clinical mastitis in the first 100 days of the next lactation compared to those that did not. Two cases of mastitis occurred during the dry period in cows that received the antibiotic treatment, compared to none in the teat sealer group, the difference was not significant. There was no difference between the treatment groups in the number of cases of clinical mastitis during the first 100 days of the next lactation (30 cases in the teat sealer group compared to 35 in the antibiotic treated group).

This is the first positively controlled study to demonstrate the efficacy of an internal bismuth subnitrate teat sealer in protecting quarters against new dry period mtra-mammary infections caused by major mastitis pathogens, particularly environmental organisms, under UK field conditions.

KEYWORDS: Mastitis, Dry cow therapy, Teat sealer, Intramammary infection.

American Association of Bovine Practitioners

Prudent Drug Usage Guidelines

The production of safe and wholesome animal products for human consumption is a primary goal of members of the AABP. In reaching that goal, the AABP is committed to the practice of preventive immune system management through the use of vaccines, parasiticides, stress reduction and proper nutritional management. The AABP recognizes that proper and timely management practices can reduce the incidence of disease and therefore reduce the need for antimicrobials; however, antimicrobials remain a necessary tool to manage infectious disease in beef and dairy herds. In order to reduce animal pain and suffering, to protect the economic livelihood of beef and dairy producers, to ensure the continued production of foods of animal origin, and to minimize the shedding of zoonotic bacteria into the environment and potentially the food chain, prudent use of antimicrobials is encouraged. Following are general guidelines for the prudent therapeutic use of antimicrobials in beef and dairy cattle.

1. The veterinarian's primary responsibility to the client is to help design management, immunization, housing and nutritional programs that will reduce the incidence of disease and the need for antimicrobials.

2. Antimicrobials should be used only within the confines of a valid veterinarian-client-patient relationship; this includes both dispensing and issuance of prescriptions.

3. Veterinarians should properly select and use antimicrobial drugs.
   a. Veterinarians should participate in continuing education programs that include therapeutics and emerging and/or development of antimicrobial resistance.
   b. The veterinarian should have strong clinical evidence of the identity of the pathogen causing the disease, based upon clinical signs, history, necropsy examination, laboratory data and past experience.
   c. The antimicrobial selected should be appropriate for the target organism and should be administered at a dosage and route that are likely to achieve effective levels in the target organ.
   d. Product choices and regimens should be based on available laboratory and package insert information, additional data in the literature, and consideration of the pharmacokinetics and pharmacodynamics of the drug.
   e. Antimicrobials should be used with specific clinical outcome(s) in mind, such as fever reduction, return of mastitic milk to normal, or to reduce shedding, contagion and recurrence of disease.
   f. Periodically monitor herd pathogen susceptibility and therapeutic response, especially for routine therapy such as dry cow intramammary antibiotics, to detect changes in microbial susceptibility and to evaluate antimicrobial selections.
   g. Use products that have the narrowest spectrum of activity and known efficacy *in vivo* against the pathogen causing the disease problem.
   h. Antimicrobials should be used at a dosage appropriate for the condition treated for as short a period of time as reasonable, i.e., therapy should be discontinued when it is apparent that the immune system can manage the disease, reduce pathogen shedding and minimize recurrence of clinical disease or development of the carrier state.
   i. Antimicrobials of lesser importance in human medicine should be used in preference to newer generation drugs that may be in the same class as drugs currently used in humans if this can be achieved while protecting the health and safety of the animals.
   j. Antimicrobials labeled for use for treating the condition diagnosed should be used whenever possible. The label, dose, route, frequency and duration should be followed whenever possible.
   k. Antimicrobials should be used extra-label only within the provisions contained within AMDUCA regulations.
   l. Compounding of antimicrobial formulations should be avoided.
   m. When appropriate, local therapy is preferred over systemic therapy.
   n. Treatment of chronic cases or those with a poor chance of recovery should be avoided. Chronic cases should be removed or isolated from the remainder of the herd.
   o. Combination antimicrobial therapy should be discouraged unless there is information to show an increase in efficacy or suppression of resistance development for the target organism.
   p. Prophylactic or metaphylactic use of antimicrobials should be based on a group, source or production unit evaluation rather than being utilized as standard practice.
   q. Drug integrity should be protected through proper handling, storage and observation of the expiration date.

4. Veterinarians should endeavor to ensure proper on-farm drug use.
   a. Prescription or dispensed drug quantities should be appropriate to the production-unit size and expected need so that stockpiling of antimicrobials on the farm is avoided.
   b. The veterinarian should train farm personnel who use antimicrobials on indications, dosages, withdrawal times, route of administration, injection site precautions, storage, handling, record keeping and accurate diagnosis of common diseases. The veterinarian should ensure that labels are accurate to instruct farm personnel on the correct use of antimicrobials.
   c. Veterinarians are encouraged to provide written guidelines to clients whenever possible to describe conditions and instructions for antimicrobial use on the farm or unit.

Presented by the Bacterial Resistance and Prudent Therapeutic Antimicrobial Use Committee. Board approved March 1999.