Practical considerations for implementation of artificial insemination programs for beef cattle

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Abstract

The beef industry is increasingly taking advantage of effective methods available to synchronize ovulation in beef females. In addition to wide genetic choices possible with artificial insemination, estrus synchronization consolidates calving, increases calf age at weaning and with each season, increases average days postpartum at the start of breeding season. Variability in artificial insemination pregnancy rates occur from year to year, but should not prompt substantial changes in procedures. Inadequate nutrition limits reproductive success. Skillful managers balance reproductive output and feed expenditures. Adequate weight gain during the third trimester is critical to reproductive performance and timely reminders from a tool called Management Minder can ensure important dates are not missed. The Estrus Synchronization Planner converts a diagram of an estrus synchronization protocol to a calendar with specific dates and times for action. Attention to detail is important from nutritional management and execution of the estrus synchronization protocol to deposition of semen. Economic efficiency of a breeding program increases if number of bulls needed for natural service are reduced following artificial insemination. Balance number of bulls needed post artificial insemination with knowledge and experience of the artificial insemination program and relative risk aversion. Early pregnancy detection allows staging of pregnancies and adds value for marketing, management and assessment of reproductive response. Minimize stress of activity and animal movement to reduce embryonic loss. Estrus synchronization systems can be adapted to a variety of production environments, enabling increased opportunities to pursue value-added genetics.

Keywords: Artificial insemination, estrus synchronization, Management Minder, beef cattle, pregnancy rate, Estrus Synchronization Planner

Introduction

Fixed time artificial insemination (FTAI) works and the beef industry is increasingly taking advantage of effective methods available to synchronize ovulation in beef females. More and better information (e.g. genomically enhanced expected progeny difference) is available from breed associations to make profitable selection decisions. Furthermore, marketing options are available to capture investments made in genetics. Economic advantages of estrus synchronization (ES) and artificial insemination (AI) programs were demonstrated in multiple settings.[1-3] Challenges come from applying known systems to a wide range of production environments. Portable corrals and turn-key breeding services are available and can overcome some limitations. However, ES and AI do require additional animal handling and may influence time in drylots or trap pastures and subsequent movement to grazing resources. A variety of stressors can increase embryonic loss and management must understand and minimize potential for problems. Need for a sound year-round nutritional program to support optimal reproduction is recognized; however, sometimes it is difficult to achieve with adverse weather and other real-world challenges. This manuscript will outline several tools that can help implement ES and AI programs and aid in year-round management. Application of ES and AI require attention to details from semen acquisition to clean up with natural service sires. Broader production system impacts will be outlined that may be influenced by reproductive management choices.

Expectations

It is important to start an AI program with sound expectations of results. Variability in AI pregnancy rates will occur from year to year. Sticking with a basic plan and working on refinement of details over several years is a good path towards improvement, rather than large changes each year.

Reviews of embryonic loss place fertilization rate at 85 - 100%[4,5] serving as an upper limit to pregnancy expectations. Embryonic mortality data[5] in low-yielding dairy cows and heifers were summarized; for every 100 head inseminated, 90 fertilized ova were present on day 4, 60 were pregnant on day 28, 56 remained pregnant on day 90, and 54 calved. Evidence that beef cattle experience less embryo loss than lactating dairy cattle can be drawn from benchmark calving distribution data. Summary of 2010 - 2107 CHAPS™ database reported that 60% of mature beef cows calved in the first 21 days of the calving season (https://www.ag.ndsu.edu/DickinsonREC/chaps-software-1). Proportion of multiparous beef cows that calved in the first 21 days of the 2017 spring season to natural service sires (18 populations, 2,372 calvings) at the Meat Animal Research Center was 72.4%, where cow pre-calving body condition averaged 6.3 (Bob Cushman, personal communication).

A field trial with 34 Missouri herds that used FTAI after a CoSynch + CIDR protocol had AI pregnancy rates that averaged 65% (1,963/3,015). Pregnancy rate to AI ranged from 60 - 69% in herds ≥ 100 head (n = 15) and 63 - 86% in herds < 50 (n = 10).[6] There was no difference between pregnancy rate to AI (n = 13,942 first inseminations) and natural service (n = 6310 first inseminations) based on nonreturn rates (mean ± SD, 57.5 ± 9.2; 58.0 ± 13.1, respectively);[7] however, rates were more variable with natural service. Focus of an ES and AI program is often on female management to improve pregnancy rate, but variation in sires was also a factor. Standard deviation of service sires on conception rate was ± 3.68% and over ± 8% for herd years.[8] Pregnancy rate per natural serviced female (n = 2,316) averaged 53.7% and was lower for yearling bulls than those ≥ 2 years.[9]

Cow management

When working with producers to incorporate AI for the first time, best case scenario is to start a year in advance to ensure nutrition and health foundations are in place. Evidence of good nutritional management includes pregnancy rates of ≥ 88 - 90% in a 60-day breeding period and ≥ 50% calving in the first 21 days. Identifying subgroups of animals for AI that calved early and have appropriate body condition is another option for starting an AI program. Some herds may benefit from an intermediate step of using synchronization with natural service sires before shifting to AI. Factors that influence postpartum interval to estrus were reviewed extensively.[10,11] Inadequate nutrition is generally the first limiter in common production settings. Body condition at calving reflects energy status during late gestation and when inadequate, postpartum interval is extended, even if energy is adequate during lactation.[12] A body condition score (BCS) ≥ 5 (1 = emaciated; 9 = obese) at calving is considered a good target. Under a nutrient-rich environment, average postpartum interval to estrus was 55 - 67 days, depending on sire bred.[13] In a summary of studies conducted in more typical commercial settings, proportions of cows cycling prior to estrus synchronization were 64% for multiparous and 55% for primiparous cows and increased 7.5% for every 10-day interval from ≤ 30 and > 90 day post calving.[14] Body condition score assessed at initiation of synchronization reflected a curvilinear pattern, with peak AI pregnancy rates in cows with condition scores of 5 and 6 and lower rates for cows with BCS < 5 and > 7.[15]

If selecting a subgroup of cows for AI, use cows with a BCS ≥ 5 at calving, 40 days or more postpartum at AI and in a positive energy balance. A synchronization protocol that contains a progestin may induce noncycling (late calving and marginal BCS, BCS ≈ 4) cows to cycle and conceive earlier. If a progestin insert is used, cows should be ≥ 20 days postpartum at insertion. Cows that are anestrus before synchronization often have similar pregnancy rates as cycling cows[16] although few, if any, cows in these studies would be considered to be in deep anestrus. Primiparous cows with BCS < 5 are less likely to be induced to ovulate compared to multiparous cows.[14] Lower-cost semen could be targeted for thin or late calving cows, as pregnancy response will be lower.

Planning for timely year-round management

Herds with good reproductive responses have good year-round management. The optimal time to cost-effectively put condition back on cows, if needed and account for fetal growth, is between weaning and calving. Unfortunately, the start of the third trimester often passes without notice and more importantly action. Third trimester is the period of greatest fetal growth and cows that do not gain weight during this time are losing body condition. An earlier than normal weaning date may help retain cow condition and conserve forage resources when limited. More days available to add fetal weight gain lower requirements for rate of gain and energy density of diet; however, if delayed too long, even a high-concentrate diet may not achieve needed performance.

A web-based tool (Management Minder), available at www.KSUBeef.org/managementminder or www.iowabeefcenter.org/software.html, was developed to remind producers of key dates related to management, e.g. start of third trimester. The Management Minder can act as a personal assistant that helps organize and manage a cattle operation. Many annual activities occur in association with the start of key events: breeding soundness examinations need to be scheduled and completed before the start of the breeding season, high-magnesium mineral needs to be started before grazing and vaccine must be on hand before preconditioning. Timely action can increase productivity and profit. When hours of sleep are short, such as during calving, the Management Minder provides an easy reference for upcoming action items. This program will create a list of activities and dates that can be imported into electronic calendar systems such as Outlook, Google or Yahoo and be available on a smart phone.[17] Table 1 provides examples of activities that can be added to a calendar. Calendars can be made for clients that include recommendations for health and reproductive management.

Getting details right

Numerous systems studied could be used for synchronization of estrus and ovulation in beef heifers and cows; however, a short list of protocols has been developed that are efficacious and minimize handling with the goal of increased likelihood of producer success.[18] These recommended protocols are listed in major US semen company sire catalogs, at www.beefrepro.info or covered in online media coverage of an annual symposium dedicated to application of reproductive technology at www.appliedreprostrategies.com.

The Estrus Synchronization Planner was designed to help users select an estrus synchronization protocol from the short list of recommended protocols and administer it correctly. To use the planner, MS Excel or Open Office software is necessary. The tool can be downloaded free of charge at the Iowa Beef Center at http://www.iowabeefcenter.org/estrussynch.html and detailed help in using the tool is available on that website. A favorite feature of the tool is the calendar created that indicates dates, times, and products to be given based on selections of the user. Many estrus synchronization projects require coordination of a number of individuals and the calendar produced can serve as a communication and planning tool with everyone involved. The calendar is particularly useful when planning longer-term progestin systems to ensure days are counted correctly. A common problem with implementing protocols is getting the various commercial products for gonadotrophin releasing hormone (GnRH) and prostaglandin $F_{2\alpha}$ ($PGF_{2\alpha}$) confused. Specific commercial products to be used can be selected so that the calendar shows the trade name, as well as the date and time of day of administration.

For FTAI systems, there is a recommended 3 - 6 hours window when insemination should occur. Planning should include the time it takes to gather and work cattle, daylight hours and working temperatures to set a target insemination time for the group. Based on the time indicated to start AI, the planner calculates when $PGF_{2\alpha}$ should be given. If the planner shows this to be in the middle of the night, the time to give $PGF_{2\alpha}$ can be reevaluated. An alert is given if the number of females in the group cannot be inseminated in a 3 hour interval, based on the estimate of number inseminated in 1 hour. Do not synchronize any more females than can be inseminated in a given setting within a window of 3 - 4 hours.

A new MultiGroup version of the planner was released in 2018 that allows users to incorporate up to 12 groups of cattle over a 12 month period. For example, replacement heifers might be scheduled for AI on May 1, followed by 2 year olds on May 15th and mature cows on May 16. This version also includes a supply sheet that can summarize quantity of supplies such as vials of GnRH, insemination sleeves or semen. First time users of this version will benefit from watching the short instructional video to understand the process that allows plans for the multiple groups to be developed and saved. This tool is also free and can be found at the same Iowa Beef Center website as the original planner.

Table 1. Example of activities that can be added to electronic calendars from the Management Minder

Date	Item
1/11/2019	Replacement heifer check weight #1
1/15/2019	Check calving supplies and facilities
1/22/2019	Get started on shopping for new sires
1/30/2019	Begin evening feeding 2 year olds
2/13/2019	Calving begins 2 year olds (+280 d)
2/16/2019	Begin evening feeding mature cows
2/22/2019	Record calving body condition score mature cows
3/1/2019	Calving begins mature cows
3/10/2019	Replacement heifer check weight # 2
3/10/2019	Plan AI protocol yearling heifers
3/23/2019	Body condition score sires
3/23/2019	Semen and Trich test bulls, vaccinate and deworm
3/23/2019	Order products for spring vaccinations and parasite control
3/23/2019	Get supplies and semen ordered for AI
3/23/2019	Plan AI protocol
3/25/2019	Pre-breeding vaccinations yearling heifers
3/25/2019	Reproductive Tract Score/Pelvic measurements
4/1/2019	Start High Mg mineral
4/1/2019	Pre-breeding vaccinations mature cows
4/1/2019	Test calves for BVD-PI
4/1/2019	Implant non-replacement calves
4/15/2019	Grass turnout
5/9/2019	AI begins yearling heifers
5/22/2019	Turn in herd sires mature cows
5/22/2019	Record breeding body condition score cows

While not as robust as the Excel versions, a mobile friendly version of the planner can be accessed at http://www.estrussynch.com/. It does require an internet connection to use it. In the mobile version, drop down menus provide choices and when the inputs are complete, the program will send an email with dates of activities as outlined. This tool works particularly well for starting discussions on estrus synchronization planning and a first look at calendar dates.

Progestin treatment

Two commercially available progestins are available for use in heifers; melengesterol acetate (MGA®, Zoetis, Madison, NJ) and Eazi-Breed CIDR® insert (CIDR, 1.38 g progesterone, Zoetis). If uniform, consistent daily intake of MGA can be achieved, it is less expensive and requires less handling to administer. Because of intake variation, some prefer feeding MGA in a portion of a limit-fed diet; however, there are successful operations that feed MGA in a total mixed ration. Longer term estrus synchronization protocols with either MGA or CIDR lend themselves to combining palpation for pregnancy, reproductive tract scores and/or pelvic area with the start of progestin treatment. Vaccination for reproductive diseases can also be done at this time without negative impacts on fertility.

The advantage to an intravaginal progestin device is that it is much easier to know that each animal received progestin. A relatively low percentage of vaginal inserts may be lost, particularly in heifers and drylot settings. Shortening the tail of the insert is used to reduce loss from curious pen mates playing with tail. However, the tip of a shortened tail can cause irritation. A vaginal discharge can occur in association with vaginal inserts and tails on the inserts contribute to severity of discharge.[19] Various pathogens were identified at insert removal[20] and they remained at insemination, even though the vaginal discharge was reduced.[19] Presence of organisms alone may not reduce fertility; however, producers should strive for cleanliness during insertion and recognize that excessive contamination can be harmful.

Producers ever vigilant on cost control have attempted to reuse CIDR inserts. Autoclaves, more common in laboratory settings, use heat and pressure to sterilize items. Compared to new or used but not autoclaved CIDR inserts, used autoclaved CIDR inserts produced higher concentrations of progesterone in cows for the first 24 hours after insertion.[21] Progesterone concentrations in heifers from on farm "sterilization" methods of used inserts were compared to new and autoclaved used CIDR inserts.[22] On farm methods were dishwasher, microwave, toaster oven, dryer, boiling, and 60 days outdoor exposure to environment. None of the cleaning methods produced a release pattern of progesterone similar to new CIDR inserts. Inserts stored outside were more discolored and produced the lowest concentrations of progesterone. Cleaning and storage can have negative impacts on the integrity of components of the CIDR and its tail. Time needed for an initial cleaning (before sterilization) and storage space and location between uses are additional complicating factors.

Injections

For synchronization protocols to work, treatments should be given as prescribed and also should comply with Beef Quality Assurance Guidelines. Newer working chutes provide better control and access to preferred injection sites in the neck in contrast to many older models. Contrary to some assertions, injecting prostaglandin in the top rump (closer to the ovary) did not improve response.[23] In the 2016 - 2017 Beef Quality Audit, injection site lesions in the round continued to decrease in dairy and beef cows but were still at 15 and 7% of samples, respectively.[24] Survey information from the dairy industry indicated 32 - 70% of injections were given in hindquarters.[25,26]

Semen Quality and Handling

Each step from collection of semen to deposition in the female must ensure semen quality and viability for best pregnancy success. A thorough breeding soundness exam assessing concentration, motility, and morphology of sperm should be performed before semen is frozen. Small, independent collection operations may not offer a complete semen analysis as part of the freezing process. Use semen processed at a Certified Semen Services (CSS) lab. When receiving semen, do not expose canes or canisters above the frost line in the neck of the tank for longer than 8 seconds. Start the AI season with a full tank of liquid nitrogen to raise the frost line and minimize semen exposure to damaging temperatures during high-use periods. Implement a semen inventory system to minimize risk of exposure to elevated temperatures when locating straws. If using an electronic thaw unit, test the temperature with a calibrated thermometer before the season begins. Replace card thermometers annually. Thaw only as much semen as can be inseminated in 10 -15 minutes.[27] Do not allow straws to touch while thawing. Follow provider recommendations for semen thawing temperature and time. Use a timer when thawing semen and do not guess. After thawing, protect semen from cold and heat shock. Keep the thaw box, AI gun, scissors, and equipment clean. Straw cutters can be difficult to clean and should be replaced rather than using a dirty cutter. Semen packaged in 0.25 ml straws are more susceptible to handling damage than 0.5 ml straws, because of the greater surface to volume ratio. To avoid damage, movement from tank to tank or from tank to thaw unit should not exceed 3 seconds.[28]

Although the uterine body is considered the optimal site of deposition of semen, correct placement was lower in several studies in dairy cattle and further evaluation indicated placement in the uterine horn resulted in higher conception rates in some cases. When conception rates from body insemination were > 60%, little advantage resulted from deposition in the uterine horn.[27] This could be a reflection that uterine horn insemination is not easily confused with uterine body insemination, but the cervix can be confused with the uterine body. Cervical deposition of semen does reduce conception rate and should be avoided. Deposition of semen in the uterine horn did not improve conception rate with sexed semen.[29,30]

Bull management post AI

In many instances, a single FTAI or some AI period is followed by the use of natural service sires to complete the breeding season. This raises the issue of how many natural service sires are needed to ensure adequate coverage at the estrus following synchronization. A number of factors will influence the number and timing of females in estrus following ES and AI and subsequent need for bull power. A low AI pregnancy rate increases the number of females returning to estrus. The reason for a poor response could affect the distribution pattern of return to estrus. If females were anestrus and the synchronization protocol did not induce ovulation, the depth of anestrus would determine when they might show estrus. In contrast, if response of females to synchronization was good but semen quality and fertilization rate were poor, returns to estrus would likely be more synchronous.

Nonpregnant heifers returned to estrus in a biphasic pattern following a 5 day CoSynch + CIDR protocol. First peak was at 7 days after FTAI and the second at 17 - 18 days.[31] Maximum percentage of heifers returning to estrus on any 1 day was 3.5% of the original group. Pregnancy rate to FTAI was 51%. A maximum of 18% of nonpregnant cows (3.1% of total group) returned to estrus on any given day following a CoSynch + CIDR timed AI protocol (pregnancy rate 55%), with 13% in estrus the day before peak and 16% in estrus the day after peak.[32] A pressure-sensing mount detector (HeatWatch) fitted 13 days after FTAI identified 86% of nonpregnant heifers in estrus from days 15 through 26 with a maximum of 10% of the original group in estrus on any 1 day[33] and pregnancy rate to FTAI was 56%.

Some information is available regarding bull to female ratios when natural service sires are used on synchronized females. In single-sire mating groups of estrus-synchronized females (n = 2,316), pregnancy rates did not differ with bull to female ratios of 1:7 to 1:51.[9] An optimal bull to heifer ratio of 1:25 was identified when comparing 1:50, 1:25 and 1:16 for females synchronized with MGA. More variation between replicates was noted with the 1:50 group[34] which agrees with the wide variation between bulls in number of offspring sired in multi-sire groups.[35] Information on bull to female ratios is summarized[36] when a final pregnancy rate was reported with AI pregnancy rate. A normal ratio was defined as 1:20 - 1:30 and half the normal ratio was 1:50 - 1:60. Final pregnancy rates were similar when half the normal rate was used after ES and AI compared to the normal ratio and to normal ratios with total natural service.[36] The 2007 - 2008 NAHMS survey reported an average of 23.7 females per mature bull.[37] Inability to reduce the number of natural service sires following AI increases costs and may negate economic benefits of AI.[38]

The importance of breeding soundness examinations and monitoring mating activity is heightened for use of natural service with synchronization or for cleanup natural service following ES. Yearling bulls have lower pregnancy rates when breeding estrus-synchronized females than bulls 2 years and older[9] and should be used sparingly. Use of a single sire was more efficient than multi-sire pastures for bulls mated to estrus-synchronized heifers, based on the lack of difference in pregnancy rates between the two groups.[39] However, it is potentially riskier, since practical systems to evaluate libido prior to the breeding season are lacking. When bull workload is expected to be high, the use of bulls ≥ 2 years old in a relatively smaller pasture is advisable. The ability to rotate bulls in and out after a few days of breeding would be advantageous, but may not be practical.

Pregnancy rates to AI were 27% higher in females that displayed estrus at or before FTAI.[40] Estrus detection or an estrus detection aid could monitor estrus response before FTAI to inform decisions of bull numbers needed post AI when conditions warrant. Experienced AI technicians may note when estrus response is low in females they are inseminating, but may have a difficult time quantifying to what degree without deliberate accounting.

Timing of bull exposure post AI depends on priorities that could range from maximizing early pregnancy regardless of sire, to marketing of AI-bred females. If marketing AI-sired seedstock females, accurate identification becomes increasingly important with increasing DNA testing for paternity. As noted previously, return to estrus can be scattered from days to weeks after AI. For research purposes, natural service sires are typically withheld for 10 - 14 days after the last AI followed by early pregnancy detection with ultrasonography from 30 - 90 days after AI. When using ultrasonography between days 35 and 100 of pregnancy, calving date was predicted ± 15 days, 95% of the time when scanning under field conditions and measuring the first image of the following: crown rump, head biparietal, head length or truck diameter.[41] The authors suggested that confirming breeding date should be limited to females with only 1 breeding before ultrasonography or that breedings are separated by > 1 estrous cycle. Earlier diagnosis of pregnancy may require follow up due to embryonic or fetal loss. This can add cost, but there is more value in pregnancy diagnosis if stage of pregnancy and or sex is determined. Early pregnancy diagnosis can be part of routine management to reduce stocking rate in yearling heifer pastures by removing nonpregnant heifers. Regardless of whether individuals pregnant to AI sires will be marketed as such, early pregnancy diagnosis monitors success of an AI program or the first natural service cycle. In the case of an unusually low pregnancy response, the manager has more time and options to minimize the negative impact of this result and make needed changes to correct the issue. Based on stage of pregnancy, females can be grouped for more precise feed or calving management and administration of precalving vaccinations that affect colostrum quality.

Avoiding stressors

Nutrition

Stressors from heat, sudden diet changes, transportation and disease can affect embryonic loss. Good global nutrition is paramount to reproductive success; however, sometimes management choices contribute to short-term or unintended reductions in intake and or energy. Weaned replacement heifer calves are often placed in a drylot and remain there until after an AI period. Several studies support the concept that increased embryonic loss may occur in heifers that have not had grazing experience post weaning and subsequently have negative or reduced gains when first introduced to summer pasture.[40] Compared to heifers with grazing experience during development, naïve heifers took significantly more steps as measured by pedometers on the first few days after grass turnout and had lower ADG.[42] Either because of lack of grazing experience or youthful interest in exploring new surroundings that does not leave time for grazing, average daily gain is reduced early in the grazing period.

Abrupt nutritional changes can influence embryo survival. Heifers were assigned to a pasture allowance of either twice maintenance requirements (H) or 80% of maintenance (L) for 10 days before AI. The day after AI, using the same pasture allowances as pre-breeding, heifers were allocated to 4 treatments: LL, HH, LH, and HL. Embryo survival was lowest in the HL group and did not differ among the other treatments.[43] As variable weather conditions influence forage availability before and during the breeding season, overestimating forage availability could reduce reproductive response. Use of historical stocking rates based on number of cows as compared to actual mature cow weight could contribute to errors in estimating available forage.

Transportation

Limited information is available on effects of transportation stress following breeding; however, transportation increases concentrations of cortisol,[44,45] an indicator of stress. Heifers transported 350 miles on days 1 - 4 after AI had earlier conception dates and higher AI pregnancy rates than heifers moved on days 8 - 9 and 28 - 29.[46] Flunixin meglumine given 13 days after AI and before 4 - 6 hours of transportation reduced pregnancy loss in cows.[45] Data are not available that addressed the effect of distance or method of moving on level of stress. Realities of weather and nutritional availability at pre- and post-move sites can force timing of movement. Weaned heifer calves acclimatized to handling had reduced concentrations of cortisol and were older at puberty compared to controls.[47] There were no beneficial effects of acclimatization in mature cows; however, higher pregnancy rates were associated with lower cortisol concentrations.[48] Perhaps cows with favorable temperament scores are less susceptible to stress in general, including transportation. If movement must occur after insemination, utilize low-stress handling techniques and try to either move before day 5 when the embryo is still in oviduct or after complete attachment of embryo to uterus on day 42.

Heat

Overtime, most beef herds adapted breeding periods that fit their environment and avoid heat stress issues during breeding. However, variable weather conditions can result in unusually warm weather around the time of AI. Heat stress has the biggest negative impacts during the final stages of ovulatory follicle development and until the embryo reaches the uterus.[49] Animals adjust to warmer temperatures over time, so early uncharacteristically warm days can cause more problems than if the same temperatures occurred later in the year. Some producers moved the calving season so that peak forage quality more closely matches peak cow lactation requirements. However, in these programs, reproductive responses are vulnerable to weather variability. Short-term management options are limited if natural shade is not available. Vaginal temperature peaked 1 hour after peak environmental temperature and recovered after daylight hours passed.[50] Therefore, during periods of heat stress, cattle should be worked as early as possible in the morning and avoid work in the late afternoon or evening when heat loads are still high.

Systems impacts of adding ES and AI programs

Calving management

Choice of timing of the calving season involves many considerations[51] especially weather since newborn calves are vulnerable to weather extremes. A common concern for producers trying FTAI for the first time is that all the calves will be born on a day when the weather is dangerous. Calving from a FTAI occurred over a 16 - 21 day interval, depending on sire. [52] Maximum number of calves born on any day ranged from 15 - 20% of those calving to the FTAI.[52] Another report of calving distribution following FTAI in cows from 12 locations and multiple sires reported a range in duration of pregnancy from 258 - 296 days.[53] Producers that incorporate AI programs generally report less calf death loss at calving.[3,54] Preparation and focus on calving, in addition to use of high-accuracy calving ease sires may explain this result. Regardless, planning for calving a synchronized group of females should include plans for shelter and management in response to common local weather variability and labor availability.

Postpartum Interval

In an ideal estrus synchronization program, more calves are born early in the calving season and are older and heavier at weaning. This is true for AI[1] or natural service sires.[55] The advantage for subsequent breeding seasons is that more cows will have a longer interval between calving and start of the next breeding season. As a result, more females should be cycling at the start of the breeding season and be more likely to conceive early. Depending on initial calving distribution, there is often an incremental improvement in cows conceiving earlier in the breeding season for several years. This enables use of a shorter breeding period, while maintaining or improving final pregnancy rate.[2] A short breeding period (45 - 60 days) even for the extremely well managed herd, risks a stressor (i.e. disease, heat, or nutrition) that could affect embryo survival not evident until after bulls are pulled. This emphasizes the importance of continuing to identify cows returning to estrus late in the breeding season or after season. Leaving bulls longer, combined with early pregnancy diagnosis, is a good risk-management tool. Cows pregnant beyond a targeted calving window should be marketed. If late breeding cows are retained as part of the main herd, the advantage of ES on increasing the days postpartum at breeding can disappear.

Health

Application of ES protocols and AI in cows involves gathering and sorting of cow/calf pairs typically 3 times in 8 - 12 days. Whether it was because they were observing the calves more closely or activities associated with ES increased exposure of calves to pathogens, ES was one of a number of factors determined to have an association with incidence of respiratory disease in calves.[56] This observation should serve to remind us that when we incorporate new management practices such as ES that a broader system view of potential impacts should be taken into consideration to avoid unintended consequences.

Breeding season length

Breeding season length is among many reproductive management choices producers make. Rebreeding 2 year old females is a challenge for many operations and consequently the use of ES and AI avoided. A short breeding season for replacement heifers (< 40 days or less) can position heifers for better reproductive success as 2 year olds. Table 2 illustrates how many 21 day estrous cycles could occur in 2 year old females during their second breeding season, based on the date of conception as a yearling heifer and a range of postpartum intervals to first estrus of 60, 90, and 120 days. In a high-nutrient availability setting (body condition score 6.1 before breeding), postpartum interval for 2 year old females averaged 55 days.[13] However, in nutrient-restricted situations, the interval could be > 120 days.[57] Even with a 60-day postpartum interval, heifers that conceive late their first breeding season may only cycle once in a 63-day breeding season. Assuming a 60% conception rate, 40% of late bred heifers are at risk to be not pregnant. With longer postpartum intervals, even a heifer that conceives by day 21 the first season is at great risk to be not pregnant the second season. Leaving bulls out longer may be a good management decision, because bred females are typically worth more than nonpregnant females. However, those that conceive in the first 21 days as yearling heifers have greater longevity in the herd and produce almost 2 calves more in weaning weight over a lifetime.[58] If nonpregnant yearling heifers can be profitable, then breeding enough yearling heifers to achieve the desired number of replacements after 20 - 30 days of breeding is advantageous. Excess late bred pregnant or nonpregnant heifers are marketed.

Table 2. Influence of postpartum interval to first estrus and the first conception date as a yearling heifer on number of possible estrus cycles during second breeding season.

Conception date as yearling heifer relative to mature cow breeding season	Days postpartum at start of mature cow breeding season	Postpartum interval: 60 days	90 days	120 days
		Estrous cycles in 63 days		
day -14	94	3	3	1.8
day 1	80	3	2.5	1.1
day 21	59	2.9	1.5	0.1
day 42	38	2	0.5	0
day 63	17	1	0	0

Conclusion

All available technology will be needed to meet the world demand for protein in the next 30 years. Estrus synchronization and AI, although increasing in use, are still underutilized in US beef operations. The growing list of genetic selection tools will provide pathways to address production challenges and help reach value-added markets. As the dairy industry uses beef sires, data collection mechanisms in place at dairies may provide sire fertility data previously unavailable to the beef industry. Improved understanding of sire to sire variation in fertility and factors influencing early embryonic loss represent areas that will likely improve outcomes of future AI programs. Technology that makes it easier to collect and share data will help unravel the mechanisms. A variety of stressors can cause embryonic loss and management must understand the potential culprits and minimize. Selection increased growth and performance of the beef herd, and may have changed tolerance to stress. When the environment is less than optimal, low stress-tolerance may increase embryonic loss or reduce pregnancy rates. No one questions the need for a sound year-round nutritional program to support optimal reproduction. The challenge in implementing AI programs is maintaining adequate nutrition to support reproduction in a cost-effective fashion in the face of droughts, floods and world trade issues with impacts on commodity prices. Good animal husbandry and a sharp pencil or detailed spreadsheet remain important tools.

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Conflict of interest

There are no conflicts of interest to declare.

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