ECONOMIC COMPARISONS OF NATURAL BREEDING VERSUS ARTIFICIAL INSEMINATION OF BEEF COWS

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Artificial insemination (AI) will not increase the reproductive efficiency of the herd (i.e. number of females that cycle out of all females during the breeding season) over that obtained with natural service. Nor will AI increase the effectiveness of breeding opportunities (i.e. first service conception rate is unlikely to be higher than natural service). Consequently, do not expect to produce any more calves using AI than already realized through natural service.

However, an AI program involving synchronization of estrus does have several advantages over natural service. More control of matings is possible which allows for a shortened breeding and calving season.[1] For example, if a ranch typically maintains a 63-day breeding season, each female has potentially up to three opportunities to become pregnant (because the bovine female has a 21-day estrous cycle). On the other hand, with synchronization of estrus, the same three opportunities to become pregnant could be accomplished in a 45-day breeding season. Cows that calve early during the calving season have older and heavier calves at weaning.[2] The cows also have a longer postpartum period before breeding. Additional advantages of AI include decreasing the number of bulls owned over the long-term, and allowing access to better genetics, particularly bulls with high EPDs for desirable traits.[3]

One economic pay-off of AI comes form marketing more total calf weight since more calves are born earlier in the calving season and have more days to grow before weaning. In addition, AI offers potential to improve herd genetics, particularly replacement females, which are a valuable economic commodity to progressive ranchers.

Determinants of Reproductive Efficiency

Reproductive efficiency is critical in ultimately determining whether AI is more cost-effective than natural service as a management procedure. Obviously, the more cows that are cycling at the start of the breeding season, the greater the opportunity to settle each one via AI. Several factors play a key role in determining the length of the post-partum interval and subsequent number of cycling cows observed during the breeding season. These factors include 1) Body condition of cow at calving, 2) distribution of calving over time, 3) age of dam at calving, and 4) reproductive health of individual cows. Out of all these factors, body condition score (BCS) at parturition appears to be the single most important factor affecting post-partum interval to estrus and pregnancy percentage in primiparous and multiparous cows under natural service.[4-6]

Widespread poor body condition (BCS <5) of the mature cow herd is a tell-tale sign that nutritional compromise is the likely culprit for low reproductive efficiency.[7,8] Nutrient intake insufficient to maintain adequate body energy reserves decrease ovarian and corpora luteal weights and inhibit the pituitary release of LH.[9] Inadequate protein intake has the same effect on luteal function.[10]

Spitzer and co-workers[11] have shown that greater BCS at calving resulted in more cows in estrus and more cows pregnant by 40 and 60 days into a breeding season. The percentage of cows in BCS 4 (n=73), BCS 5 (107), or BCS 6 (n=60) at calving that subsequently exhibited estrus within the first 20 days of the breeding season were 42±6%, 54±4%, and 63±9%, respectively. By the end of a 60 day breeding season, 74±4%, 90±3%, and 98±6%, respectively, of the cows within these same cow groups had exhibited estrus. Other researchers have documented a similar influence of BCS on post-partum reproductive function.[12-15]

A good plane of pre-calving and post-calving nutrition is necessary for the cow herd to exhibit estrus early in the post-partum period and to re-breed during a restricted breeding period. The effect of nutrition on postpartum reproduction depends somewhat on whether nutritional compromise exists before or after calving.[16] In general, under natural breeding conditions, the nutritional differences that exist at calving, as estimated by precalving BCS, are more important in determining postpartum interval than those that exist after calving. The effects of BCS at calving on the length of the postpartum interval are nonlinear, with the effects being greatest at a very low BCS (<4). Once the cow herd enters a BCS range of 5-7, swings in postpartum nutrition have less impact on postpartum interval. At BCS >7, a declining nutritional plane has a negligible effect on postpartum interval.

The same attention to pre-partum nutritional BCS applies to AI. The best candidates for this reproductive management procedure are going to be those cows that calved in good body condition and early in the calving season.

Adjunct Management Procedures to Shorten Post-Partum Interval

Several adjunct management procedures have been identified that can shorten the postpartum interval of first calf heifers, but they require an intensive management commitment on the part of the producer. These procedures include bull exposure, short duration of cow-calf separation, and early weaning.

Studies[17-19] have shown that when teaser bulls are placed with primiparous heifers at any point in time within the first 40 days postpartum, and allowed to run with heifers throughout the postpartum period, the postpartum interval to first estrus is shortened (typically by about 16 days). Testosterone-treated teaser cows work equally well.[20]

Interruption of suckling by using short duration (48 hours) calf removal has proven an effective management technique to trigger estrus in otherwise anestrus females.[21] Suckling normally delays LH release and the onset of estrus in lactating beef cows.[21] This physiologic response is due to an apparent negative feedback loop mediated by suckling on a mammary-hypothalamo-hypophyseal somatosensory neuronal pathway of the dam.[21] Temporary calf removal is more effective when combined with a progestin-based estrus synchronization system.[21,22] Cows <u>must</u> have a body condition score 5 or greater to show good results.[21]

In thin (BCS 4 or less) first-calf heifers, short duration calf removal has not been effective in initiating estrus. A workable alternative has been to early wean calves at side.[22-26] This approach would be suitable in situations of drought, or when a ranch has a large number of first-calf heifers comprising the cow herd, or for heifers that calve later in the calving season. Cyclic activity in cows in marginal body condition (BCS 4) would also improve following early weaning of calves.

The post-weaning performance of early weaned calves (< 90 days of age) is quite satisfactory provided that their special nutritional needs are met. Due to low body weight (usually <300 lbs.) and associated limitations in dry matter intake, early-weaned calves require a diet that is highly palatable, high in protein, and relatively low in roughage.[27] Lusby and Gill[27] have previously reviewed ration ingredient makeup and guidelines for feeding early weaned light-weight calves. With the exception of a risk of coccidiosis, very few health problems occur in early weaned calves.[27]

Short-term supplementation with fat has had a positive effect on stimulating cyclic activity in postpartum cows in marginal body condition (BCS 4). Research has shown that thin cows have a shorter return to estrus and, subsequently, more likely to conceive when 1.5-1.75 kg (3-4 lbs.) of whole cottonseed or whole sunflower seed are fed daily beginning 3 weeks before and extending 3 weeks into the breeding season1.[28] It is important to restrict usage to these two plant oils because, unlike other oilseeds, they contain relatively high concentrations of linoleic acid.[28] The linoleic acid content of cottonseed and sunflower seed has an apparently stimulatory effect on follicular cell growth.

In cows in adequate body condition (BCS 5 or greater), postpartum interval can be shortened using previously described techniques of bull exposure and short duration calf removal. In addition, treatment with prostaglandin (Lutalyse, Upjohn) between 29 and 42 days after calving[29] and feeding ionophore antibiotics, beginning in the immediate postpartum period and continuing through the breeding season,[30,31] have had a beneficial effect on shortening the postpartum interval in treated cows. Monensin sodium (Rumensin 80, Elanco Animal Health) is the only ionophore currently approved for use in pastured mature breeding cows. Monensin sodium is fed at the rate of 200 mg/head/day incorporated into either a protein or protein-energy supplement.

Estrus Synchronization Programs

An excellent in-depth review of synchronization of estrus in postpartum beef cows was published by Odde in 1990.[32] Progestogens, prostaglandins (prostaglandin $F_{2\alpha}$ and its analogues), progestogen-estrogen combinations and progestogen-prostaglandin combinations were summarized in this review for their efficacy in this reproductive management procedure.

Since this review, GnRH has been evaluated for its pretreatment effect on synchronizing follicular development, estrus response, precision of estrus, and conception rate. Examples of protocols used include:

- one GnRH injection 7 days before a prostaglandin $F_{2\alpha}$ (PGF2α) injection followed by detected estrus and AI (referred to as Select Synch protocol)[33]
- GnRH at day 0 + PGF2α at day 7 + GnRH at day 9 followed by AI at 16-24 hours after the second GnRH injection (referred to as Ovsynch protocol)[34]

- GnRH at day 0 + PGF2α at day 7 + GnRH with timed insemination at day 9 (referred to as CO-synch protocol)[34]
- GnRH at day 0 + Intravaginal progestogen controlled internal device release (CIDR) for 7 days + plus prostaglandin $F_{2\alpha}$ at day 7 + GnRH with timed insemination at day 9[35]

Synchronization of estrus implies the manipulation of the estrous cycle or induction of estrus to bring a large percentage of a group of females into estrus at a predetermined time.[32] Insemination protocols can vary. For instance, females may be inseminated according to estrus, i.e. cows will be observed for signs of estrus and inseminated approximately 12 hours after observed estrus. Alternatively, cows may be unobserved for signs of estrus but instead inseminated at a fixed (predetermined) time (referred to as timed breeding, breeding by appointment, or mass breeding).[32]

Ideally, an estrous synchronization system should elicit a fertile, tightly synchronized estrous response in a high percentage of treated females. Distribution of estrus or degree of synchrony is important when evaluating a system's potential for timed breeding. Methods of evaluating synchronization systems include:[32]

- estrous response (percentage of females showing estrus out of those treated)
- synchronized conception rate (percentage of females conceiving out of those inseminated)
- synchronized pregnancy rate (percentage of females conceiving out of the total treated)
- pregnancy rate at various stages of the breeding season

The various progestogens that have been utilized over the years include 1) daily injection of progesterone, 2) orally administered 6-methyl-17 acetoxy-progesterone (MAP) or 6-chloro-6-dehydro-17-acetoxyprogesterone (CAP), 3) orally administered dihydroxyprogesterone acetophenide (DHPA), 4) progesterone-releasing intravaginal devices (PRID), and 5) melengesterol acetate (MGA) fed orally.[32]

Until recently, the classic progestogen-estrogen combination for synchronization of estrus involved a 9-day implant (Synchro-Mate B – Sanofi Animal Health) containing 6 mg norgestomet plus an injection of 5 mg of estradiol valerate given at the time of implant. Due to removal of this drug from the market, a controlled internal device release (CIDR - Bioniche, Inc) containing progesterone has filled this void.

Because prostaglandin $F_{2\alpha}$ and its analogues cause luteolysis, they are used to synchronize estrus in cattle.[32] The three prostaglandin products approved for synchronization of estrus in cattle in the US are prostaglandin $F_{2\alpha}$ (Lutylase – Upjohn Co.), cloprostenol (Estrumate – Schering-Plough Animal Health Corp.), and fenprostalene (Bovilene – Diamond Laboratories). In general, synchronization of estrus has been performed using a one injection or a two injection protocol given 10-12 days apart. If cattle are distributed equally across the day of the estrous cycle, approximately 70% of the cycling females should show estrus after the first injection.[31] Approximately 70% of the remaining females typically show estrus following the second injection. Expect first-service conception rates of 50-68%.[32]

When progestogen-prostaglandin combinations are used, a prostaglandin is administered at or near the end of a progestogen treatment. For example, in one study,[36] during the first 3 days of the breeding period, 59% of females receiving CIDR + PGF2α treatment exhibited estrus versus just 15% for untreated controls and 33% for those females receiving a PGF2α treatment alone. Subsequent pregnancy % for the 31-day breeding season were 50%, 55%, and 58% for control, PGF2α, and CIDR + PGF2α, respectively.

With regards to the Select-synch, Ovsynch, and CO-synch protocols that use GnRH as an integral part of estrus synchronization, expect at least a 50% first-service conception rate.[33-35] Temporary calf removal for the 48 hour period between the PGF2α and second GnRH injection, tends to improve conception rates by nearly 10%.[34]

The most important aspect in choosing the most practical estrous synchronization program to use, a producer must have an accurate (realistic) estimate of the number of females that have resumed normal estrous cycles and fertility following calving. As mentioned previously BCS is critical in dictating which cows are likely to cycle early in the breeding season as well as those that have had ample time for uterine involution (at least 45 days post-calving) prior to the start of the breeding season.

Economic Analysis

The following inputs are required in order to complete a realistic economic analysis of AI:

- Animal information
  - ⇒ <u>Accurate</u> (realistic) estimate of number of cycling females
- Cost information
  - ⇒ Drugs
  - ⇒ Semen
  - ⇒ Labor
  - ⇒ Miscellaneous supplies
  - ⇒ Supplemental feed
  - ⇒ Investment in facilities, gomer bulls, semen tank, etc.
- Revenue Information
  - ⇒ Weight advantage (no. calves born early in calving season)
  - ⇒ Premium on genetics

For beef cattle producers that elect to use AI as a management procedure, little potential exists for increasing profitability if he/she does not know the costs and returns of estrus synchronization in combination with AI. A complete description of the herd characteristics is needed when determining if expected returns are greater than the economic costs of estrus synchronization and AI programs. The following parameters should be considered when evaluating feasibility of AI: 1) production seasons of the herd, 2) calving distribution and body condition score (BCS) of the exposed females, 3) EPDs of the natural service bulls as well as the AI bulls, 4) certain variable costs (e.g., labor, drugs, semen) and certain fixed costs (e.g., facilities and equipment).

Attendees of this seminar will be shown a spreadsheet-based decision aid that should help producers make a more complete evaluation of the potential success and profitability of implementing an estrus synchronization and AI program in their herds. Thus, commercial beef cattle producers will benefit from knowing whether AI can be economically justified in their operations given the present level of reproductive performance in their cow herd.

Copies of the model will be made available upon request.

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