The Impact of Using Artificial Insemination versus Natural Service for Florida Beef Cows

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Introduction

Estrous synchronization and artificial insemination (AI) are reproductive management tools that have been available to beef producers for over 40 years. Synchronization of the estrous cycle has the potential to shorten the calving season, increase calf uniformity, and enhance the possibilities for utilizing AI. Artificial insemination allows producers the opportunity to infuse superior genetics into their operations at costs far below the cost of purchasing a herd sire of similar standards. These tools remain the most important and widely applicable reproductive biotechnologies available for beef cattle operations (Seidel, 1995). However, beef producers have been slow to utilize or adopt these technologies into their production systems.

Several factors, especially during early development of estrus synchronization programs, may have contributed to the poor adoption rates. Initial programs failed to address the primary obstacle in synchronization of estrus, which was to overcome puberty or postpartum anestrus. Additionally, these programs failed to manage follicular waves, resulting in more days during the synchronized period in which detection of estrus was necessary. This ultimately precluded fixed-time AI with acceptable pregnancy rates. More recent developments focused on both corpus luteum and follicle control in convenient and economical protocols to synchronize ovulation. These developments facilitated fixed-time AI (TAI) use, and should result in increased adoption of these important management practices (Patterson et al., 2003). Current research has focused on the development of methods that effectively synchronize estrous in postpartum beef cows and replacement beef heifers by decreasing the period of time over which estrous detection is required, thus facilitating the use of TAI (Lamb et al., 2001, 2006, Larson et al., 2006). This new generation of estrus synchronization protocols uses two strategies which are key factors for implementation by producers because they: 1) minimize the number and frequency of handling cattle through a cattle-handling facility; and 2) eliminate detection of estrus by employing TAI.

High priority needs to be placed on transferring these current reproductive management tools and technology to producers, veterinarians and industry personnel to ensure they are adopted at the producer level and to provide the necessary technical support to achieve optimum results. Because current management, breed, economic, location, and marketing options are producer specific, it is essential to ensure that transfer of this technology is not presented in blanket recommendations. Producers receiving all the necessary, applicable information packaged to include, but not limited to, protocol administration, economic implications, and genetic improvements to the cowherd are more apt to implement these tools into their management systems and achieve positive outcomes as a result. Without timely transfer of this technology within the United States, our research products and technology will be more effectively utilized in foreign countries competing with the United States to produce and market high quality, uniform beef products. The recent development of estrous synchronization protocols for TAI in beef cows has the potential to alter reproductive performance in numerous herds.

The primary reason U.S. beef producers cite for the lack of widespread AI use to breed heifers and cows is limited time and labor (NAHMS, 1998). Development and methods of implementation of TAI protocols are essential for producers, because they reduce the "hassle" factors associate with estrous synchronization and AI. Unless, owners of commercial cowherds aggressively implement reproductive and genetic improvement, the U.S. will lose its competitive advantage in high-quality beef production. International players that are more technically astute and competitively advantaged will position themselves to dominate the production and sale of beef worldwide. For example, the adoption of TAI systems in Brazil has increased exponentially (592%) during the past 17 years, whereas as the increase in beef semen available for use in the United States has only increased moderately during the same time period (Figure 1). Most of the cattle operations in Brazil implanting estrous synchronization systems and TAI are large, extensive commercial operations using Bos indicus (mainly Nelore cattle) breeds. Which is quite similar to operations in Florida. Brazilian cattle producers have realized: 1) the value of estrous synchronization to overall fertility of beef herd; and 2) the increased value of a calf sired by a bull with enhanced performance and carcass characteristics.

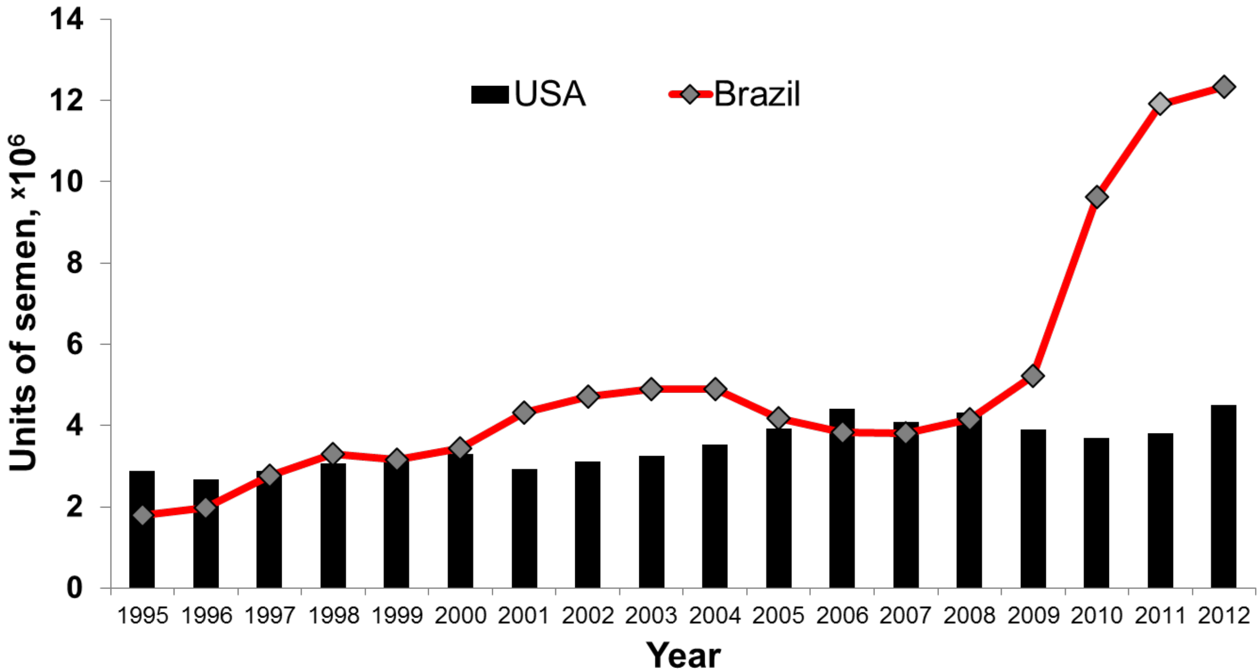

Figure 1. Differences in semen sales between the United States[a] and Brazil[b] from 1995 to 2012. ([a]NAAB and [b]ABSIA).

Development of estrous synchronization methods for TAI.

Initial estrous synchronization systems focused on altering the estrous cycle by regressing the CL with an injection of PG followed by detecting estrus between 18 and 80 hr after the injection. Once systems involving a single injection of PG became successful, researchers focused on multiple injections of PG to further reduce days required for heat detection and AI (Lauderdale et al., 1974; Seguin et al., 1978). The next generation of estrous synchronization systems involved the use of exogenous progestins (MGA and CIDR), which (while administered) prevented estrus from occurring. Progestins were used to delay the time of estrus following a natural or induced luteolysis and extend the length of the estrous cycle (Brown et al., 1988; Lucy et al., 2001). Not until the discovery that growth of follicles in cattle occurs in distinct wave-like patterns (Fortune et al., 1988) were scientists able to embark on the third generation of estrous synchronization systems. Controlling follicular waves with a single injection of GnRH to cows at random stages of their estrous cycles causes release of luteinizing hormone leading to synchronized ovulation and luteinization of mostly large dominate follicles (≥ 10 mm; Garverick et al., 1980; Bao and Garverick, 1998; Sartori et al., 2001). Consequently, a new follicular wave is initiated in all cows within 2 to 3 d of GnRH administration. Luteal tissue that forms after GnRH administration is capable of undergoing PG-induced luteolysis 6 or 7 d later (Twagiramungu et al., 1995). A drawback of this method, however, is that approximately 5 to 15% of cows are detected in estrus on, or before, the day of PG injection, thus reducing the proportion of females that are detected in estrus and inseminated during the synchronized period (Kojima et al., 2000; Lamb et al., 2001). Based on this foundation, much of the current work has focused on three areas: 1) development of reliable protocols that rely solely on TAI;

2) development of systems that require a maximum of three animal handlings; and 3) research to ensure that the systems are successful in both anestrus and estrous cycling females at any stage of the estrous cycle. This review is an update on these developments for synchrinzation of the estrous cycle in cows.

Overview of the CIDR Device

The CIDR is an intravaginal progesterone insert, used in conjunction with other hormones to synchronize estrous in beef and dairy cows and heifers. The CIDR was developed in New Zealand and has been used for several years to advance the first pubertal estrus in heifers and the first postpartum estrus in cows. The CIDR is a "T" shaped device with flexible wings that collapse to form a rod that can be inserted into the vagina with an applicator. On the end opposite to the wings of the insert a tail is attached to facilitate removal with ease. The backbone of the CIDR is a nylon spine covered by progesterone (1.38g) impregnated silicone skin. Upon insertion blood progesterone concentrations rise rapidly, with maximal concentrations reached within an hour after insertion. Progesterone concentrations are maintained at a relatively constant level during the seven days the insert is in the vagina. Upon removal of the insert, progesterone concentrations are quickly eliminated.

Retention rate of the CIDR during a seven-day period exceeds 97%. In some cases, vaginal irritation occurs resulting in clear, cloudy or yellow mucus when the CIDR is removed. Cases of mucus are normal and does not have an impact on effectiveness of the CIDR. Caution should be taken when handling CIDRs. Individuals handling CIDRs should wear latex or nitrile gloves to prevent exposure to progesterone on the surface of the insert and to prevent the introduction of contaminants from the hands into the vagina of treated females. The inserts are developed for a one-time use only. Multiple use may increase the incidence of vaginal infections.

Initial CIDR/$PGF_{2\alpha}$ Protocols for Cows

During the seven days of CIDR insertion, progesterone diffusion from the CIDR does not affect spontaneous luteolysis. Assuming all cows have 21 day estrous cycles, there will be two populations of females after six days of CIDR treatment: females without corpora lutea and females with corpora lutea more than six days after ovulation. All females, therefore, have corpora lutea that are potentially responsive to an injection of $PGF_{2\alpha}$. Although most research data indicates that only about 90% of corpora lutea in cows more than six days after ovulation regress promptly to an injection $PGF_{2\alpha}$, only about 60% of the females will have corpora lutea at the time of $PGF_{2\alpha}$ treatment (assuming that spontaneous corpora lutea regression beings about 18 days after ovulation). Therefore, about 95% of the females treated with the FDA approved CIDR/$PGF_{2\alpha}$ protocol are synchronized to exhibit estrus within a few days of CIDR insert removal. However, more than 95% of the treated females will be synchronized to exhibit estrus if estrous behavior is monitored for five days after removal of the CIDR insert.

An advantage of a progestin-based estrous synchronization protocol is that administration of progestins to prepubertal heifers and postpartum anestrous cows have been demonstrated to hasten cyclicity. When suckled beef cows were assigned randomly in replicates to one of three groups (Lucy et al., 2001): 1) untreated controls, 2) a single intramuscular (IM) injection of 25 mg $PGF_{2\alpha}$ ($PGF_{2\alpha}$ alone), or 3) administration of a CIDR insert for 7 d with an IM administration of $PGF_{2\alpha}$ on day 6 of the 7 d CIDR insert administration period (CIDR + $PGF_{2\alpha}$) no differences were detected between the CIDR + $PGF_{2\alpha}$ treatment group and either the $PGF_{2\alpha}$ alone or control groups for first-service conception rate for either the first 3 d of AI or the entire 31 d of AI. More cows were pregnant after either 3 d or 7 d of AI in the CIDR + $PGF_{2\alpha}$ group than in either the $PGF_{2\alpha}$ alone or the control group. No differences were detected in pregnancy rate to first services during the 31 d AI period between the CIDR + $PGF_{2\alpha}$ and either the $PGF_{2\alpha}$ alone or the control group. Therefore, insertion of the CIDR increased the synchronization rates within the first 3 d following $PGF_{2\alpha}$, resulting in enhanced pregnancy rates. A drawback of the current protocol is that $PGF_{2\alpha}$ was administered on d 6 after CIDR insertion (a day before CIDR removal). For beef producers this tends to be impractical, because the cows need to be handled a minimum of four times including an AI. Therefore, a more practical modification of this protocol is to inject $PGF_{2\alpha}$ the on the day of CIDR removal.

Development of Fixed-Time AI Protocols

For commercial beef cattle operations, the opportunity to utilize TAI protocols enhances the opportunity to incorporate AI into an operation, since these protocols do not require the hassle and labor associated with detection for estrus. Therefore, producers should consider a protocol recommended by the Beef Reproduction Task Force (Figure 2) as a desirable protocol for use in their herds. Protocols presented are based on considerable research data and field use by a group known as the Beef Reproduction Leadership Team. This group is made up of individuals representing the AI and pharmaceutical industries, veterinarians, and reproductive physiologists with active research programs in this area. Other protocols should only be considered in unique situations and with the advice of someone with extensive experience with estrus synchronization protocols. Protocols should not be altered without sound research data to support modifications. Each year the Leadership Team evaluates new researched protocols and evaluates whether they would be reliable systems for use in producers hands. Therefore, their recommendations include significant research and field data prior to making a recommendation. For more from the task force and the latest protocols see *www.beefrepro.info* or for upcoming meetings go to *www.appliedreprostragies.com*.

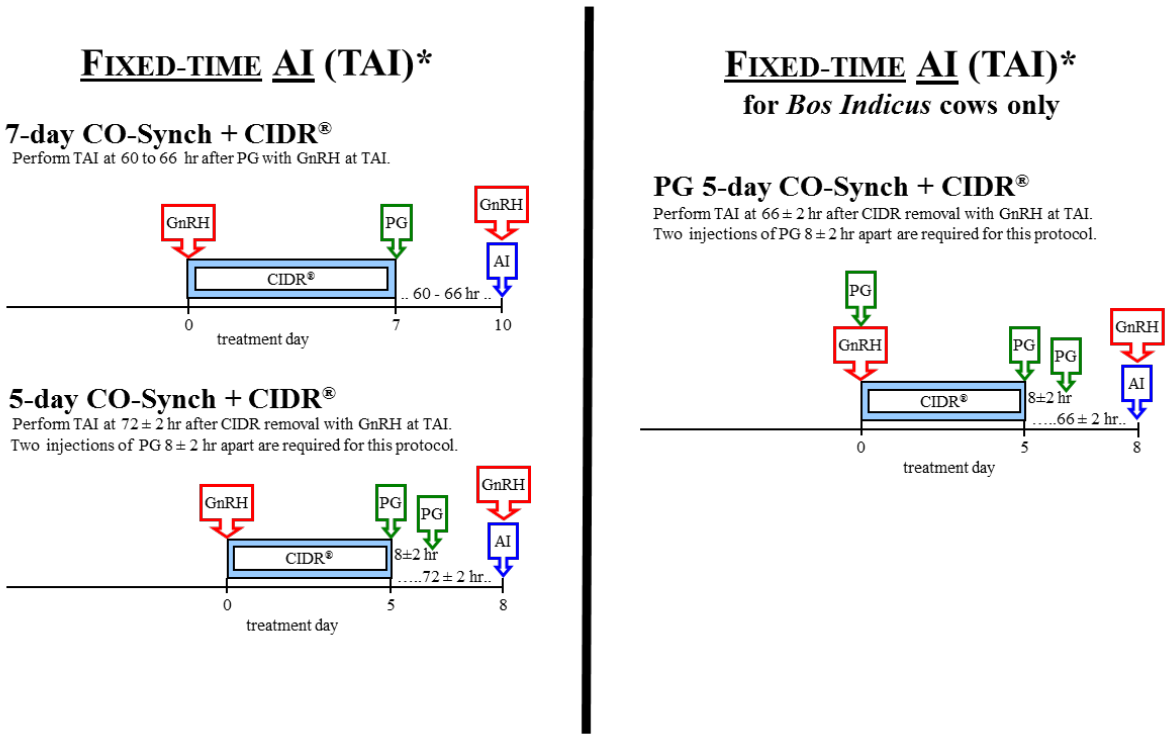

Figure 2. 2014 Fixed-time artificial insemination (TAI) protocols for cows recommended by the Beef Reproduction Task Force

With fixed-TAI protocols, all animals are inseminated at a predetermined time. For cows, fixed-TAI can produce pregnancy rates similar to those of protocols that require 5 to 7 days of heat detection. The times listed for fixed-TAI should be considered as the approximate average time of insemination. This should be based on the number of females to inseminate, labor, and facilities. Synchronize no more females than can be inseminated in the given facilities in a 3 to 4 hour period.

Two short-term protocols are recommended for cows. Cows should be inseminated between 60 and 66 hours after CIDR removal in the 7-day CO-Synch + CIDR protocol. For the shortened 5-day CO-

Synch + CIDR protocol, two full doses of $PGF_{2\alpha}$ given 8 hours apart are critical for success. Interval from CIDR removal to insemination should be 70 to 74 hours for cows. This 5-day protocol has been adapted for *bos indicus* (Brahman, Nelore) influenced cows by adding a dose of $PGF_{2\alpha}$ at the time of CIDR insertion: $PGF_{2\alpha}$ 5-day CO-Synch + CIDR. This protocol has been shown to be more effective in *Bos indicus*-based cows as compared to the 7-day CO-Synch + CIDR and 5-day CO-Synch + CIDR protocols, which are preferred for *Bos taurus*-based cows.

Utilization of the CIDR for bull breeding

To many producers AI is too technical or time consuming, yet many producers feel that with the development of fixed-TAI protocols AI might be a technology that can be utilized to generate a greater proportion of genetically superior beef cattle. The primary reason US beef producers cite for the lack of widespread AI use to breed heifers and cows is limited time and labor (NAHMS, 1998). However, the step from using natural service without estrous synchronization to using TAI is a large jump that few producers are willing to take. Therefore, there is reason to believe that estrous synchronization for bull breeding herds is a suitable step towards altering the calving season, decreasing the breeding season length, and initiating noncycling cows to start cycling. Estrous synchronization in bull breeding herds has the potential to impact a greater number of producers, because greater than 90% of producers do not utilize AI in their current management systems. In fact, only 8.1% of beef cattle operations in the U.S. use AI management procedures regularly on replacement beef heifers or postpartum beef cows to improve reproductive management of their herds and ultimately improve profitability (NAHMS, 1997).

When estrous was synchronized for bull breeding with a single injection of PG administered at initiation of the breeding season the percentage of females detected in estrus and pregnancy rates were greater than saline treated controls (Whittier et al., 1991). In addition, when heifers were estrous synchronized with melengestrol acetate and $PGF_{2\alpha}$ and exposed to bulls, the desirable bull: heifer ratio was 1:25 or less (Healy et al., 1993). Under this premise, we (Lamb et al., 2008) designed a study to determine whether insertion of a CIDR for 7 d prior to the breeding season and removing the CIDR on the day bulls were introduced to the cowherd would alter the overall pregnancy rates, average days to conception, and the subsequent calving distribution.

Overall pregnancy rates ranged from 59.3 to 98.9% among the 13 locations. Pregnancy rates within the first 30 days of the breeding season were similar between CIDR (64.4%) and Control (64.7%), and overall pregnancy rates were similar between CIDR (89.7%) and Control (89.6%). The average day of conception after initiation of the breeding season was shorter ($P < 0.05$) for CIDR (20.1 ± 0.8 d) compared to Control cows (23.2 ± 0.8 d). Of cows conceiving during the breeding season, more ($P < 0.05$) CIDR cows (43%) conceived during the first ten days of the breeding season than Control cows (35%; Figure 3). Therefore, insertion of a CIDR prior to the breeding season failed to increase overall pregnancy rates, but did influence the average day of conception in earlier calving cows.

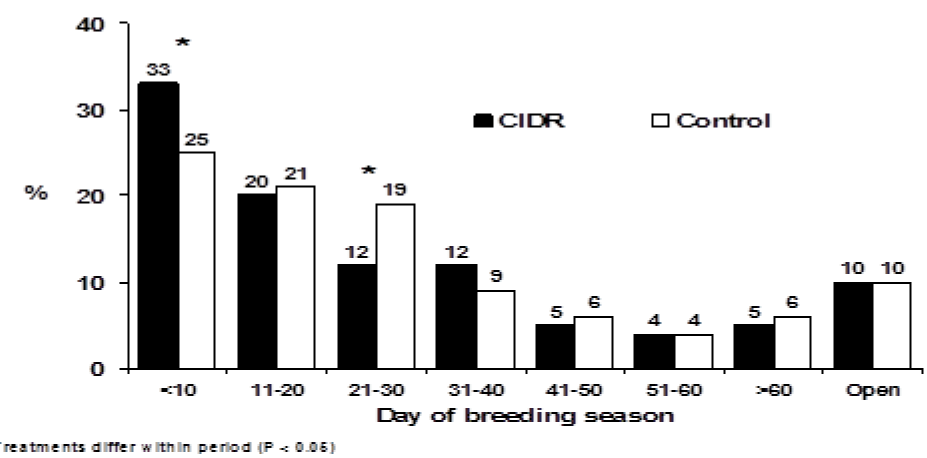

Figure 3. Proportion of cows conceiving at various intervals of the breeding season for cows in Control or CIDR treatments

Economics of Estrus Synchronization

Recently we performed an experiment using partial budget analysis to determine the economic outcome of estrus synchronization and TAI in commercial cow/calf production (Rodgers et al., 2012). Suckled beef cows (n = 1,197) from 8 locations were assigned randomly within each location to 1 of 2 treatment groups: 1) cows were inseminated artificially after synchronization of ovulation using the 7-day CO-Synch + CIDR protocol (TAI; n = 582); and 2) cows were exposed to natural service (NS) without estrous synchronization (Control; n = 615). Within each herd, cows from both treatments were maintained together in similar pastures and were exposed to bulls 12 h after the last cow in the TAI treatment was inseminated. Overall, the percentage of cows exposed to treatments that subsequently weaned a calf was greater for TAI (84%) than Control (78%) cows. In addition, survival analysis demonstrated that cumulative calving distribution differed between the TAI and Control treatments (Figure 4). Weaning weights per cow exposed to treatments were greater for cows in the TAI treatment (425 lb) than those cows in the Control treatment (387 lb). Overall, increased returns plus decreased costs ($82.32), minus decreased returns plus increased costs ($33.18) resulted in a $49.14 advantage per exposed cow in the TAI treatment compared to the Control treatment (Table 1). Location greatly influenced weaned calf weights, which may have been a result of differing management, nutrition, genetic selection, production goals, and environment. We concluded that estrus synchronization and TAI had a positive economic impact on subsequent weaning weights of exposed cows.

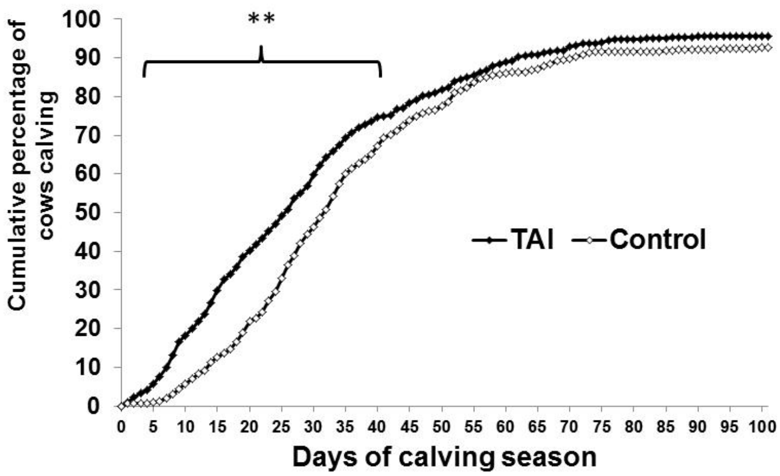

Figure 4. Survival analysis of the percentage of cows calving by day during the calving season. ** Cumulative calving percentage differs ($P < 0.05$) between TAI and Control treatments.

In the process of [illegible] we developed a mod[illegible] etermine the value of estrous synchronization in their own operations. This model has been converted into a smartphone application for Android and iPhone/iPad users and is called the **'AI Cowculator'** (Figure 5). The AI Cowculator may be downloaded free of charge and is a decision aid tool to assist producers to determine whether they should consider TAI rather than purchasing herd sires for their cow herds. We encourage producers and members of the allied industry to download the AI Cowculator and utilize this tool to assist in making bull buying and breeding season decisions.

In addition, the application contains a locator to determine where products may be purchased and technicians who can provide the service, along with additional resources and a link to the AI Cowculator social media. For users who do not have an Android or iPhone/iPad Smartphone device or would prefer to user a personal computer, an Excel-based version (Figure 6) is available and can be downloaded. For more information on the AI Cowculator, including a guide on how to use it, visit the webpage at http://nfrec.ifas.ufl.edu/programs/AICowculator.shtml..

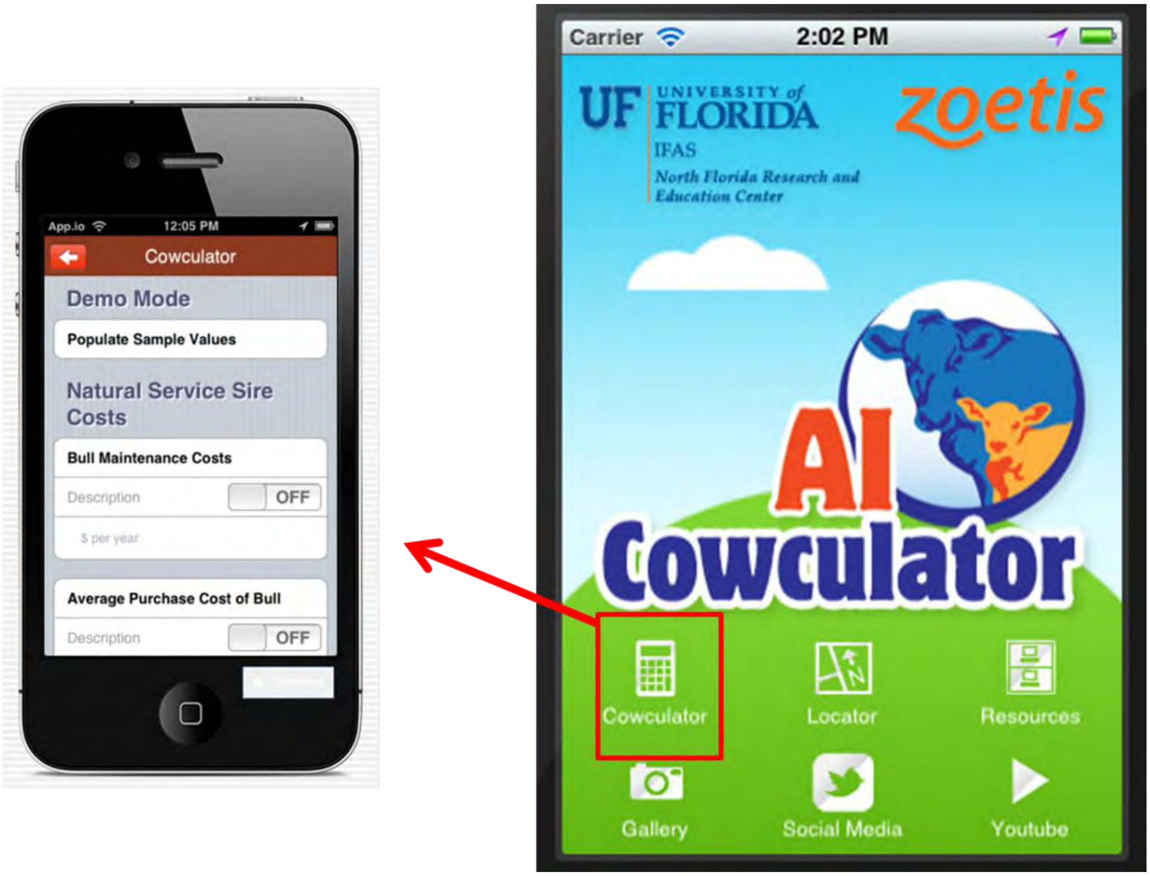

Figure 5. The AI Cowculator Smartphone Application front page.

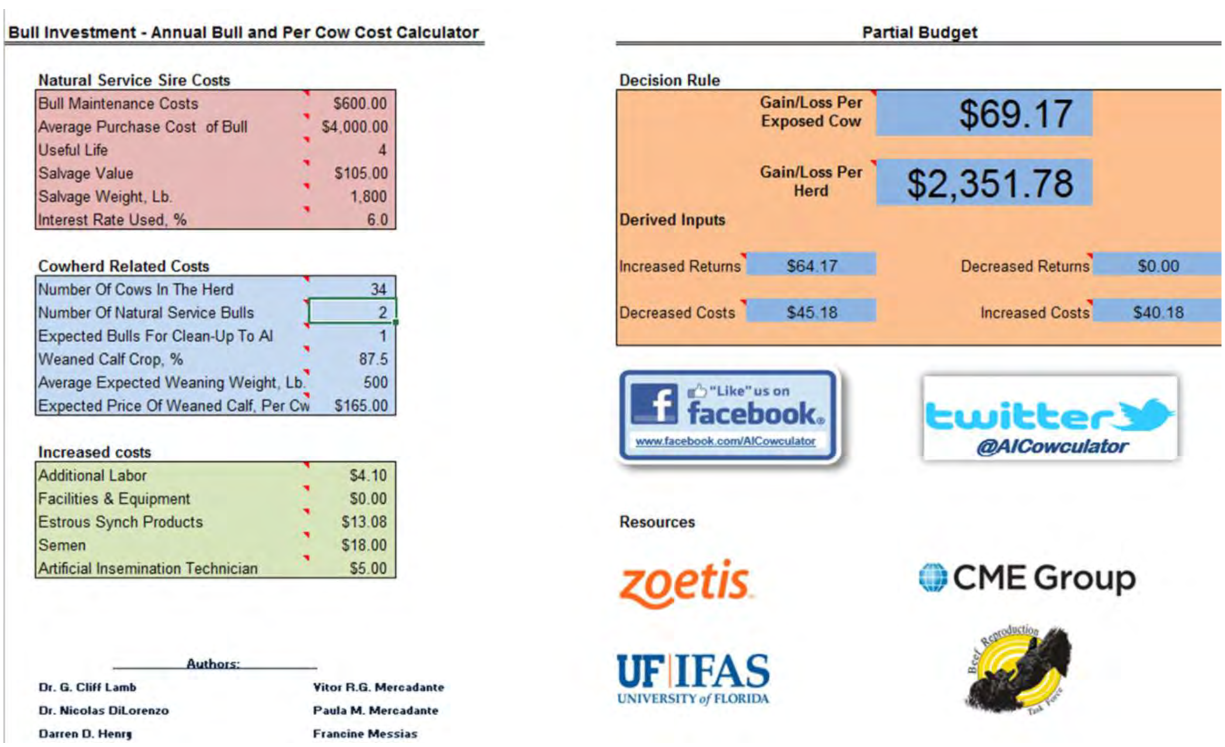

Figure 6. The AI Cowculator Excel version front page.

Table 1. Partial budget analysis for cows exposed to estrous synchronization followed by natural service compared to cows exposed only to natural service (expressed in US dollars; Rodgers et al., 2012)[1]

Item	Increased returns[2]	Decreased costs[3]	Decreased returns[4]	Increased costs[5,6]	Gain or loss	Net additional costs[7]	Additional weight, kg[8]	Breakeven price[9]
Herd sensitivity analysis:								
1	45.71	42.81	0	33.18	55.34	-9.63		
2	31.19	21.41	0	33.18	19.42	11.77	4.43	67.26
3	56.74	48.93	0	33.18	72.49	-15.75		
4	123.15	48.93	0	33.18	138.90	-15.75		
5	-10.49	37.46	0	33.18	-6.21	-4.28		
6	44.64	24.79	0	33.18	36.25	8.39	3.15	47.94
7	30.65	32.74	0	33.18	30.21	0.44	0.17	2.51
8	55.12	24.79	0	33.18	46.73	8.39	3.15	47.94
Overall[10]	47.09	35.23	0	33.18	49.14	-2.05		

[1]All returns and costs based on a weaning weight of exposed cows.
[2]Additional weight attributed to estrous synchronization (ES) and fixed-time artificial insemination (TAI) per weaning weight of exposed cows × selling price ($121.00/45.5 kg).
[3]Annual NS bull costs: annual operating costs: grazing and supplemental feed ($365.00), veterinary medicine ($40.00), annual ownership costs: depreciation ($557.00), interest cost ($151.00), death loss ($33.00): purchase price ($3270.00).
[4]Decreased returns attributed to fewer NS bulls to be culled are included as a negative value in the decreased costs calculation.
[5]Labor hours (0.41 h) per ES/TAI cow at $10.00 per hour.
[6] Supplies: Prostaglandin = $2.07/dose, CIDR = $8.76, GnRH = $2.00/dose × 2 doses,
Miscellaneous. $0.25, Semen $14.00/unit.
[7]Net additional costs as increased costs minus decreased costs.
[8]Additional weight per exposed cow to cover net additional costs at $121 per 45.5 kg (only in situations where additional costs were noted).
[9]Overall breakeven prices ($ per 45.5 kg) to cover additional costs with additional 17.5 kg pounds weaned per cow exposed to treatment.
[10]Calculated using a bull to cow ratio of 1:17.

NFREC Case Study

In 2008 we committed to incorporating an extensive AI program in the North Florida Research and Education Center (NFREC) Beef Herd, consisting of 300 cows. Prior to 2008 the breeding season was 120 days in length and we felt that committing to an estrous synchronization and AI program we could shorten the breeding season and increase calf value. In summary, committing to a TAI program required significant work and dedication, especially during the first four years because the length of the breeding season resulted in an extended calving season, such that cows were calving past the initiation of the next breeding season. However, after reducing the breeding season over five years from 120 to 70 days, almost all cows calve prior to initiation of the breeding season and are exposed to a single TAI at the initiation of the breeding season (Figure 6). The net result is a more compact calving season that has increased the value of calves (in current dollars) by $124 per calf or an annual increase in calf value for the 300 head operation of $37,260 per year (Table 2).

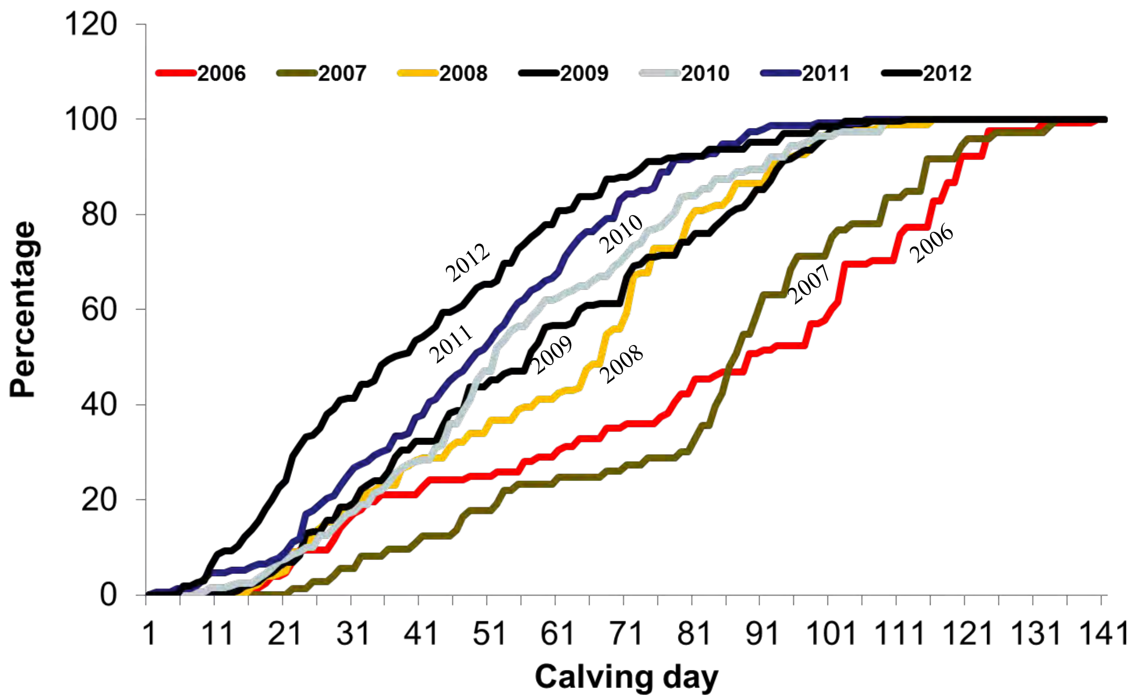

Figure 6. Cumulative calving by year for two years (2006 and 2007) prior to introducing TAI and five years (2008 to 2012) after introducing TAI.

Table 2. Breeding season characteristics and change in calf value by incorporating a TAI program into the NFREC Beef herd

	Year						
Item	2006	2007	2008	2009	2010	2011	2012
Overall PR, %	81	86	84	86	82	94	92
Mean calving day[a]	79.2	80.9	59.2	56.2	53.7	47.2	39.5
Breeding season length, d	120	120	110	88	80	75	70
Difference from 2006/2007	0	0	21.7	24.7	27.2	33.7	41.4
Per calf increase in value[b], $	0	0	$65	$74	$82	$101	$124
Per herd increase in value[c], $1,000	0	0	$19	$22	$24	$30	$37

[a] Mean calving day from initiation of the calving season

[b] Increase calf value based on increased weaning weight compared to 2006/2007 mean calving day

[c] Increase calf value based on 300 head cow herd.

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